CONTROL SYSTEM PROGRAMMING
REMOTE COMPUTING AND DATA DISPLAY

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Submitted in partial fulfillment of
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ABSTRACT

The increasing demands upon large digital computing facilities have necessitated the developement and use of a system control program to provide for continuous automatic job processing. A comparative study of two current systems was conducted. The first, CDC FORTRAN 60, is described and its advantages and disadvantages are pointed out. This system was modified by the authors to incorporate a remote (satellite) operation in a time shared mode. The second system studied was the CDC COOP MONITOR system. This system, a more complex, sophisticated control system is likewise discussed. Modifications to correct certain disadvantages of this system are shown, along with the programming necessary to provide for remote station operation in the COOP MONITOR environment.

Several other programs which were developed by the authors to improve the computing center's capability are documented. These include; (1) A graph plotting routine utilizing CDC 1604/160 computors and a CDC 165 / CalComp Plotter, (2) A large file merg sort routine, and (3) A data display "Line Printer" routine.

The authors wish to express their appreciation to Professor Mitchell L. Cotton of the U.S. Naval Postgraduate School, and to the personnel of the school's computing center for their kind consideration during the term of this thesis.

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ABBREVIATIONS

MCS	Master Control System
SCS	Secondary Control System
RHT	Running Hardware Table
SIO	Standard Input Output
AET	Available Equipment Table
AEDNT	Available Equipment Driver Name Table
RBL	Relocatable Binary Loader
ELT	Edit Library Tape
PLT	Prepare Library Tape
FWA	First Word Address
LWA+1	Last Word Address Plus One
I/O	Input/Output
BCD	Binary Coded Decimal
CDC	Control Data Corparation

1.0 INTRODUCTION

At present, the Naval Postgraduate School's computing center utilizes approximately 60% of its prime time processing short, 1 to 15 minute, "job shop", input programs. Practically all of these are of a scientific problem solving nature. Three different compiler/assembler control systems for processing these programs are currently in significant usage. They are the Control Data Corporation's "Fortran 60 System", the Naval Electronics Laboratory's "Neliac Compiler", and the school's own algebraic assembly routine, "Scrap". Of the above, the Fortran 60 System is the only system which incorporates a full control, automatic, job sequencing "monitor" system. Much more will be said about this "monitor" capability and the Fortran 60 System. The remaining 40% of the prime computing time is utilized for class laboratory instruction, maintenance and update of systems library tapes, data retrieval, schedule analysis, and other special job users.

The non-prime time, 1630 to 0800, is scheduled block time for the various developement projects and long run programs.

This environment places increasing demands upon the computing center's capabilites. Not only is improved efficiency required but also more flexibility is in demand as the programmer's talents become more and more sophisticated.

Several tasks were undertaken in the scope of this thesis project. Towards improving over-all system efficiency, a comparative study of the present Fortran 60 System and its proposed successor, "Coop Monitor/Fortran 62 System", was conducted. As a result, an outline and a discussion of the outstanding advantages and disadvantages of each system is incorporated in this thesis.

Towards improved system flexibility, two new facilities were developed. They were the implementation of an operational remote (satellite) computing station and a system's provision for automatic graph plotting of two dimensional computer

derived arrays.

The full implementation of the remote station complex is a continuing group project with much remaining to be accomplished. As an aid to those who pursue this task, several recommendations are made and suggested methods for solving some of the problems are expounded.

Besides the work accomplished in establishing the satellite station, another aspect of the center's services was improved. This was the provision of a graph plotting system. This required the developement of a plotting program for both the Fortran 60 System and a much improved and shorter Grafplot program for the Coop Monitor System. The major portion of this project was completed during the author's five week industrial tour at the Control Data Corporation, Palo Alto, California. The off-line processing of this graph plotting program was provided by rewriting, with many revisions, an existing plot drive program initially developed by the U.S. Naval Fleet Numerical Weather Facility, Monterey, California. Versions of this program were developed to operate on either the 160 or 160A CDC computers. The plotter employed is the CDC model 165/CALCOMP incremental plotter. This system has proven very effective and has enjoyed considerable usage. Although this provided an improved data output medium for the center, it has also stimulated an increased interest in utilizing the Digital Computer for project studies. Thus the center's task and effectiveness is ever increasing.

A second method of data display was provided by utilizing a new cathode ray tube, Data Display model DD65, as an "on-line" line printer. Thus it is possible to monitor the Fortran System's output listings concurrently as it is listed upon the magnetic tapes for later off-line hard copy printing.

This is a small programmed package to demonstrate a unique method of providing a "rolling page" effect on the display tube. The details of the technique are explained in section 4. It was originally planned to provide much more programming for the data display unit, however, the unexpected complexity of the Coop Monitor System limited the extent to which the authors were able to pursue this task. Modifications to the Coop Monitor System were made to couple the data display to the system. If time permits before termination of this work, the display driver routines will be completed to provide normal input/output capability between the display and the central processing computer.

Two additional projects of secondary importance were completed. They were the provision of tape control programs to enable utilization of the 1607 magnetic tape units by the CDC 160 computers when assembling programs using the CDC 160 OSAS Assembly System. The other project was the developement of a merg sort routine for large files written in 120 character BCD format. This sorting capability was a very desireable ability which had not previously been available at this installation.

2.0 FORTRAN 60 SYSTEM

The Fortran 60 System is the present fortran processor in use at the Postgraduate School. It is maintained on a system library tape, recorded in binary format, 54 words per record, see ref. 21. The records are grouped sequentially such that one record or several records may constitute a program package. These packages are referred to as being "subroutines". The first such package on the system library tape is the System Control Routine and is titled "Resident". Operation of the system is as illustrated by figure 1. The figure points out the control transfer sequence which takes place after the resident program is "bootstrapped" into the 1604 computer's memory. A short verbal explanation of the diagram follows: Initial "bootstrap" procedures are executed by the operator. This reads in the Resident program from the system library. The resident program then assumes control of the computer.

2.1 Program Control

The section of resident in which control normally resides is termed "Program Control". The function of program control is to interpret control instructions which will direct the transfer of control to some secondary control package or subroutine. All such routines must eventually return control to "Program Control". Normally program control reads its instructions from the console typewriter. These control statements may be any one of the twenty routine names shown by figure 1, or one of the eight transient program names which previously may have been "called" into core (memory) by the call routine. Some of the twenty control statements have arguments. The CDC Fortran System Manual and its update revision notices

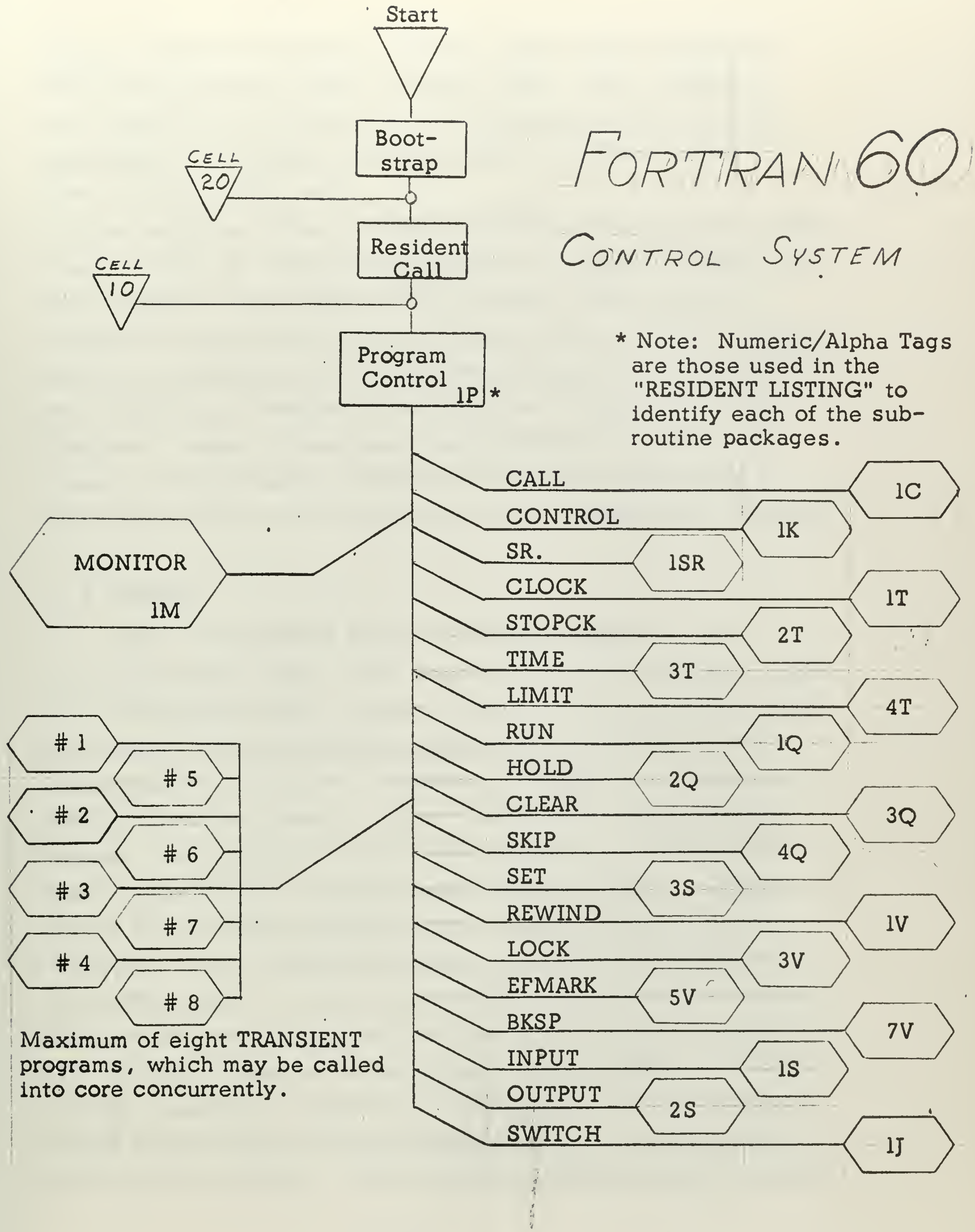

Start
Boot-strap
CELL 20
Resident Call
CELL 10
Program Control 1P *
FORTRAN 60
CONTROL SYSTEM
* Note: Numeric/Alpha Tags are those used in the "RESIDENT LISTING" to identify each of the sub-routine packages.
MONITOR 1M
CALL 1C
CONTROL 1K
SR. 1SR
CLOCK 1T
STOPCK 2T
TIME 3T
LIMIT 4T
RUN 1Q
HOLD 2Q
CLEAR 3Q
SKIP 4Q
SET 3S
REWIND 1V
LOCK 3V
EFMARK 5V
BKSP 7V
INPUT 1S
OUTPUT 2S
SWITCH 1J
1
5
2
6
3
7
4
8
Maximum of eight TRANSIENT programs, which may be called into core concurrently.

Figure 1

discuss the use of these arguments and control statements, with the exception of the statement "SR". This statement was added by the authors to provide automatic call of eight frequently used service routines such as transfer, vfylib, list, copys, verify, etc.

As mentioned before, normal operation of the control system requires that all sub-program packages, to which control may be transferred, must provide for returning control back to Program Control at the end of the directed processing sequence. Thus an examination of the resident programming, appendix IV, will find that it consists of several small programming subroutines. Some of these are self contained and some are linked to other routines which assist in the performance of the functional task for which each basic package was designed.

2.2 Monitor

It has been pointed out that "Program Control" has a very responsible task in the organization of the system, since it is the prime control routine. The next most important and the largest ofthe programming packages in resident is the processor for the control statement, "Monitor" or sometimes called "Monitor Control". It is a routine to which program control can transfer control of the computer to provide automatic processing of stacked input Fortran Programs. Monitor is by far the most complex of the resident routines and yet, compared to the second generation system, Coop Monitor, it is rather simple. A full understanding of the monitor routine is best obtained by reading this section of coding in appendix IV. Briefly, operation of the monitor is as follows. Program Control receives a statement, "Monitor,3,4." This statement could have had up to seven arguments, but for this example two will be sufficient. This statement directs program control

to transfer the arguments into the monitor control routine and then to transfer control to monitor. Monitor then tests certain flags to check if recovering from a previous job execution which lost control, requiring a forced recovery entry back to monitor. This not being the case, monitor then rewinds all output mediums, senses for input/output conflicts, initilizes for next library routine call, builds a tape assignment table, reads from the input medium (tape 3 in this example), detects a job description record, calls in the Fortran compiler, inserts the necessary arguments into the compiler, then transfers control to the compiler for compilation of the input program. If the program is successfully compiled, control is returned to monitor and monitor then transfers control to the program just compiled, this is termed "executing the program". If the program is successfully executed, it returns control back to the monitor which then returns to process the next job on the stacked input medium.

2.3 Resident Routines

The technique of transferring control of the computer has been demonstrated and we should now discuss a technique of utilizing the resident routines which are available to non-resident programs. The organization of the system provides what are called "low core" (cells 7 thru 35), entry points. These entry points are assigned to be the permanent entries to several of the programming packages contained in resident. All of these entries are shown in figure 2. Since these cells are permanently assigned, standardization limits all usage of the resident routines by non-resident programs to enter via the appropriate low-core cell. This then allows modifications to be made on the system's "Resident" routine without influencing the non-resident routines. As illustrated by

figure 2, eight of the low-core entry routines have switches which condition on whether monitor is controlling the job sequencing. If the monitor is in effect, then these eight entries are diverted in order to trap illegal monitor usage of input/output units.

The low-core entry routines are rather self explainatory. They are mostly service routines such as read, write, equipment controllers, and message handlers.

Nearly all the routines in resident fall into one of the two groups discussed. There are a few which are not in either group. These shall now be discussed.

Two similar routines which have not been mentioned are the "Input Index Register Loader" and the "Output Index Register Loader" routines. These two serve to translate the alphabetical equipment designators into the equipment codes as listed on the first page of the "Resident List", appendix IV. These equipment codes are then loaded into index registers #1 and #2. The index registers then control the proper equipment selection for the read/write routines.

Two other routines are the "Tape Read/Write" routines. These are both tape drive routines for controlling the system's magnetic tape units. The routines are commoly used by both the BCD and Binary Read/Write routines. The tape drive routines apparently were the only equipment drivers deemed worthy of individual programming. All other equipment drivers are embedded into the main body of the Read/Write routines.

There is a routine called, "Initialize for Next Call". Its function is to reset the program bias and program counter cells, #62 and #63 respectively, prior to calling each program from the library tape. This routine is bypassed if

"LOW CORE", CELLS 7 THRU 33
RESIDENT ROUTINE ENTRIES
WHICH ARE AVAILABLE TO
NON-RESIDENT PROGRAMS

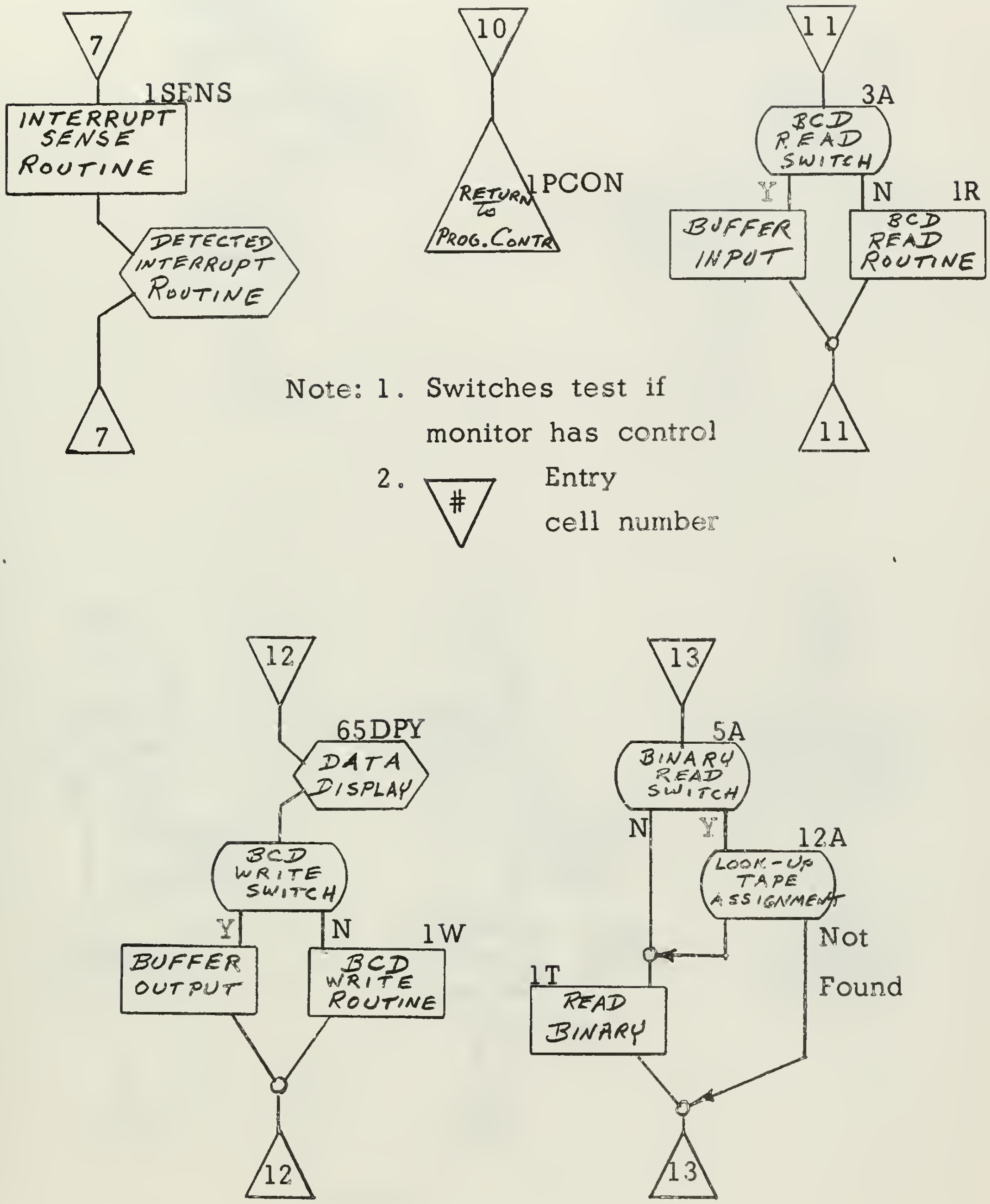


Figure 2 a

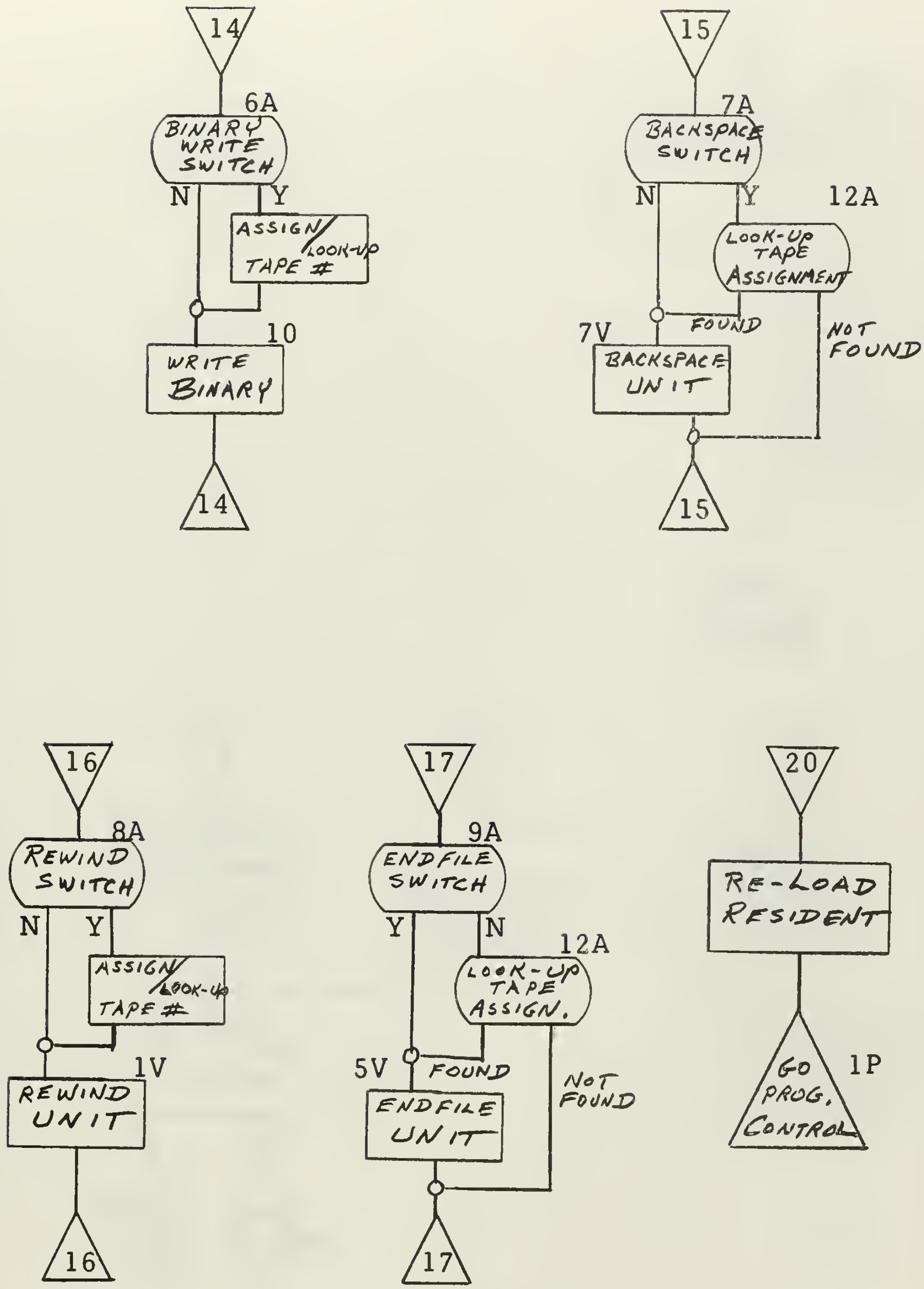

14
6A
BINARY WRITE SWITCH
N
Y
ASSIGN/LOOK-UP TAPE #
10
WRITE BINARY
14
15
7A
BACKSPACE SWITCH
N
Y
12A
LOOK-UP TAPE ASSIGNMENT
FOUND
NOT FOUND
7V
BACKSPACE UNIT
15
16
8A
REWIND SWITCH
N
Y
ASSIGN/LOOK-UP TAPE #
1V
REWIND UNIT
16
17
9A
ENDFILE SWITCH
Y
N
12A
LOOK-UP TAPE ASSIGN.
5V
FOUND
NOT FOUND
ENDFILE UNIT
17
20
RE-LOAD RESIDENT
GO PROG. CONTROL
1P

Figure 2b

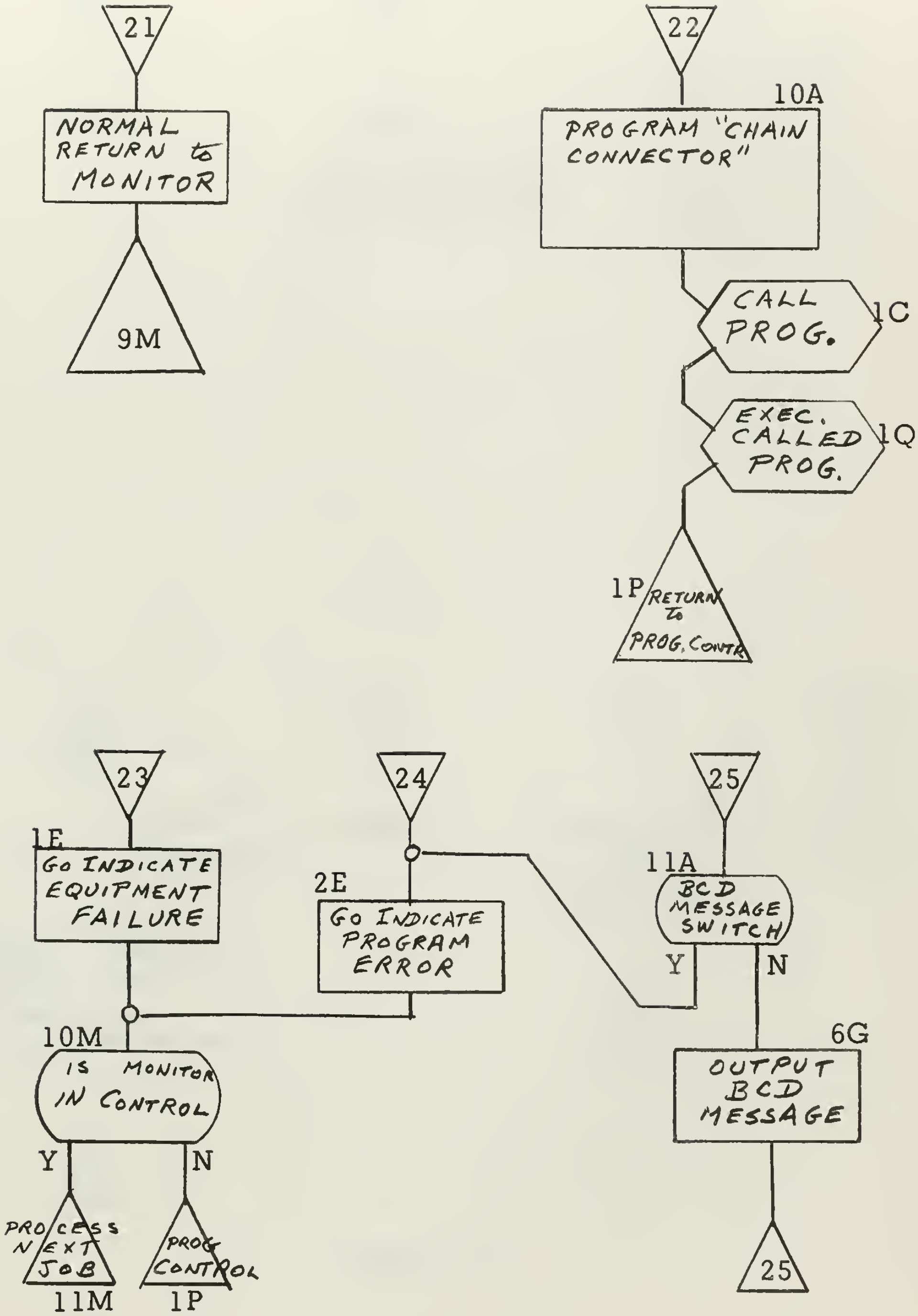

21
NORMAL RETURN to MONITOR
9M
22
10A
PROGRAM "CHAIN CONNECTOR"
CALL PROG.
1C
EXEC. CALLED PROG.
1Q
1P
RETURN to PROG. CONTR.
23
1E
Go INDICATE EQUIPMENT FAILURE
24
2E
Go INDICATE PROGRAM ERROR
25
11A
BCD MESSAGE SWITCH
Y
N
10M
IS MONITOR IN CONTROL
Y
N
PROCESS NEXT JOB
11M
PROG CONTROL
1P
6G
OUTPUT BCD MESSAGE
25

Figure 2c

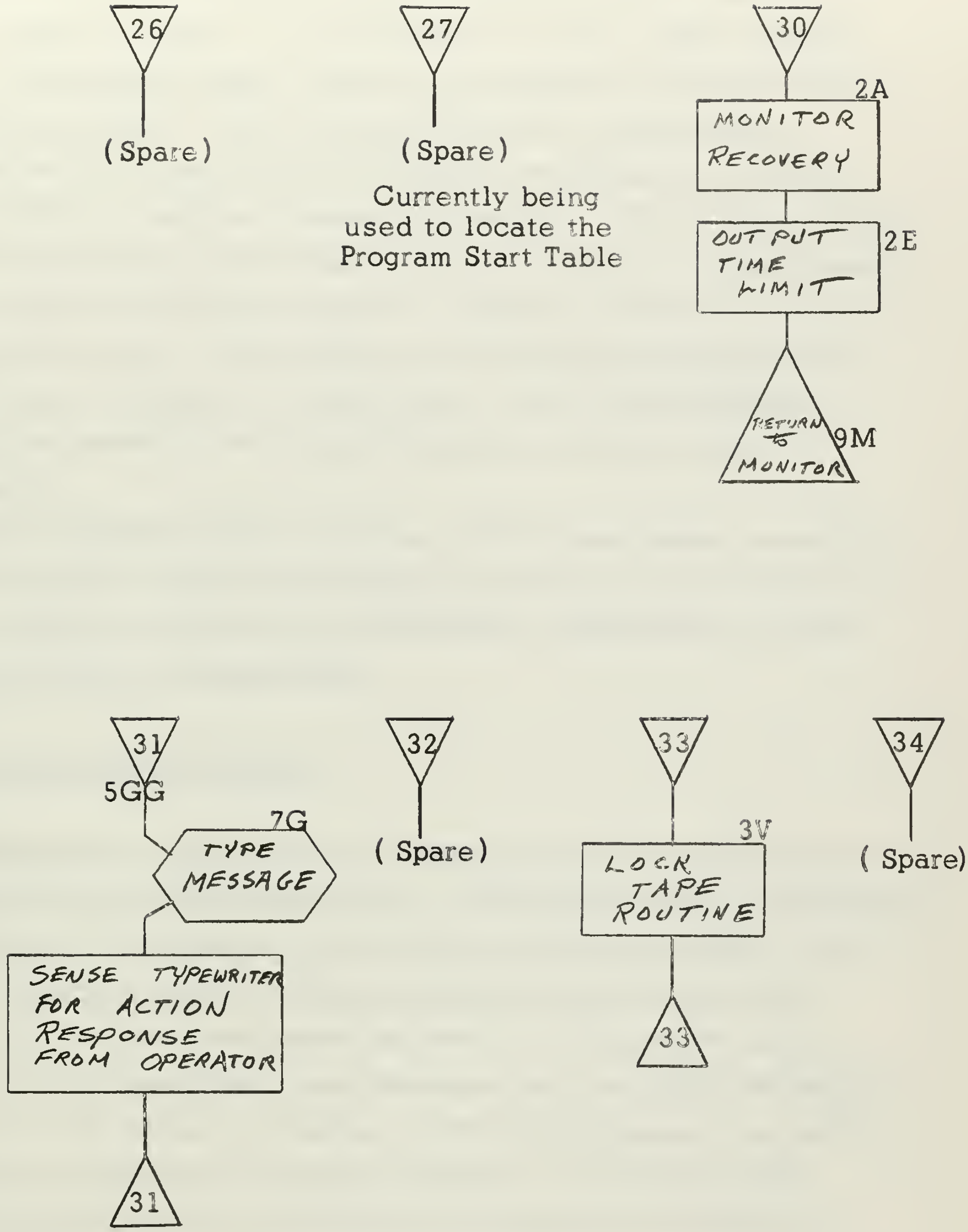

26
(Spare)
27
(Spare)
Currently being used to locate the Program Start Table
30
2A
MONITOR RECOVERY
2E
OUTPUT TIME LIMIT
RETURN TO MONITOR
9M
31
5GG
7G
TYPE MESSAGE
SENSE TYPEWRITER FOR ACTION RESPONSE FROM OPERATOR
31
32
(Spare)
33
3V
LOCK TAPE ROUTINE
33
34
(Spare)

Figure 2d

a "Hold" control statement was issued immediately prior to the issue of the "Call" statement.

One final routine to be discussed is the low-core cell #22 entry routine, "Chain". Its purpose is to call a named program from a designated library medium, then execute it without packing any arguments. This provides a method of segmenting a program which is too large to fit into the available core memory along with its "Common Storage Data Arrays". Thus the segments can be called into core one at a time for execution. Each segment over-writes the previous segment. Processed data from one segment to the next is inter-changed via designated common storage. This idea is extended one step further in the COOP MONITOR system by providing both segmenting and over-lay modes of operation.

The remaining resident routines, which were added to resident by the authors, shall be discussed in section 4.2 and section 4.4. These sections concern the "Data Display Programming" and the "Satellite Station Programming".

2.4 System Characteristics

Perhaps the most significant characteristic of the Fortran 60 System is that in its original form, its Resident control programming including all equipment control, job sequencing monitor, and basic service routines occupied only 4000 octal cells of core storage. The next most important feature of the system is its simplicity of organiztion when compared with the COOP MONITOR system. This is due, of course, to its limited scope. For some uses this simplicity is of great importance. Later the COOP MONITOR system will be discussed, at that time we shall see

that it has many advantages over the simplier Fortran 60 System. With this comparison to make, it is necessary to list the relative advantages and disadvantages of the Fortran 60 System.

2.4.1 Advantages

a. SIZE; As mentioned, the basic control programming was a modest 4000 octal cells The authors' additional programming to provide a remote satellite computing station, and cathode ray tube data display facility increased the resident size to only 5000 octal cells. This remains a fairly acceptable figure.

b. FAST STACKED JOB PROCESS TIME; The Fortran 60 monitor operates in a mode which allows re-use of the Fortran Compiler by many different jobs. This saves library reference time and hence saves process time, provided the compiler remains undamaged. The compiler compiles in memory only and uses no scratch tapes, this also leds to a very fast compilation. There are disadvantages to both these techniques which over shadow the advantages These will be discussed as listed disadvantages.

c. MINIMUM INPUT / OUTPUT UNITS REQUIRED; It is possible to operate the Fortran 60 System with only three I/O units operating. This can be a big advantage when several I/O units are inoperative or are assigned for utilization by the center's 160 computers.

d. OPERATOR SERVICE ROUTINES; A well developed repertoire of operator service routines are an important advantage to a system. Fortran 60 has several such routines such as; endfile mark tapes, rewind, lock, duplicate tape, verify, list, etc. Given a little time, the COOP MONITOR System will probable incorporate several of these routines.

e. OPERATOR TRAINING TIME; At the Postgraduate School many students are given instruction, check-out, and direct access to the school's computers. As many as 250 students may participate in these laboratory periods per year. Fortran 60, with its simplicity provides a good vehicle for instructional purposes.

f. MONITOR / OPERATOR REQUIREMENTS; The Fortran 60 monitor system requires a minimum of operator intervention to process a stacked job run. Unless one of the jobs "blows the system Off-Line", ie ; manages to execute a storage or jump instruction erroneously, the system requires no operator assists. The COOP MONITOR requires considerable operator manipulation of "Jump Keys" and loading / unloading of tapes, etc. Thus the Fortran 60 System normally requires less operator supervision.

g. LIBRARY MAINTENANCE; Library maintenance and updating should not be a daily occurance, however it is required frequently. Therefore a quick and reliable system to accomplish this task is required. Fortran 60 has three routines and a simple organization which make this an easy job. The routines are; transfer, vfylib, and list. In contrast, the COOP MONITOR System's "Libedit" routine is rather complex, is indirect via punched cards, and requires apriori knowledge concerning the current "directory" of routines on the library. It would be nice, if a directory dump routine was written and also an individual routine verify capability is required.

h. MIXED FORTRAN and SYMBOLIC STATEMENTS; Fortran 60 incorporates a fortran compatible symbolic language. Programs written for this system can inter-mix both symbolic and fortran statements on a line for line bases, if desired. For many uses such as programming shifts, logical and masking operations, searches, and other computer operations which the Fortran 60 language doesn't provide, this ability has a distinct advantage.

i. INTERRUPT ROUTINE USAGE; The only usage of the interrupt routine in the Fortran 60 System is for providing a real time clock. This would appear to be a gross neglect of such a powerful equipment capability The advantage, here, is that the provision for a satellite station operation requires much usage of this interrupt routine, hence having a system which doesn't utilize the interrupt in some complex manner is unique.

2.4.2 Disadvantages

a. COMPILER VULNERABILITY; As mentioned under advantages, the Fortran 60 compiler is normally called into the computer's memory only when initializing monitor processing of a stacked job run. Thus there exists the possibility that one of the individual jobs may possibly damage the compiler. There after the remaining jobs of the stack are forced to be compiled by a compiler which is no longer reliable. This can result in significant loss of computer and programmer's time, since the programmer is led to believe his program was incorrect.

b. SLOW TAPE HANDLING TECHNIQUES; Two standard length tape records are employed. Standard binary records are 54 words long. Standard BCD records are 15 words long, thus providing for 120 character records. This standardization is an advantage in some instances. However, the disadvantage is the cost in time which must be paid since the tape motion must be stopped and started between each record. The COOP MONITOR System solved this problem quite well. A second detriment to tape handling is the lack of utilizing the buffer input / output channels to advantage. The only usage of the buffer capability is employed under monitor process control. In this instance, very poor usage is made since there is a complete disregard for error checking during input / output operations. This slow tape handling characteristic is a serious

one since much time is spent by the system in searching the library tape. The library tape can grow to be of considerable length due to the considerations discussed as a disadvantage due to "Multiplicity of Subroutines on the Library". COOP MONITOR solved this problem by providing long variable length library records and a directory which prevents searching the full length of the library tape for routines which are "not available".

c. PROGRAM SIZE LIMITATIONS; Since Fortran 60 doesn't utilize scratch tapes during compilation, it requires that memory must hold the resident program (4000) plus the compiler (14000) plus the compiled version of the user's program plus an undefined number of cells outside the compiler which are used by the compiler for tables and temporary storage. Thus the programmer losses at least 20,000 octal cells. This is a serious limitation in many large programs. COOP MONITOR has improved this situation, but at a considerable cost in speed, due to the necessity of reloading the compiler for each job and also having to provide an intermediate and "Load and Go" tape.

d. INEFFICIENT SPACE COMPILATION; Fortran 60 compiles the full size of arrays and reserved space into the binary object program (ie. card images corresponding to the compiled program) at compile time. This coupled with the compilation limitation mentioned previously tends to further hinder efficient usage of memory space during compilation of programs. One advantage this does provide is that arrays and reserved spaces are initially cleared in a Fortran 60 program. This is not true of a COOP MONITOR compiled program.

e. MULTIPICITY of SUBROUTINES on the LIBRARY; Fortran 60 requires that all subroutines called by a program be available at compile time. The reason for this is that they are embedded into the compiled program as it is compiled. If this compiled program is then added to the library, the library is unnecessarily lengthened. This is due to the fact that versions of the existing subroutines are embedded in many programs. Not only does this scheme of compilation lengthen the library tape and thereby slow the system down, but it also creates very serious library maintenance problems. Thus the simple corrections or updating of a subroutine isn't so simple anymore. In order to correct a subroutnie, it is necessary to re-compile all programs which use the subroutine. This is due to the embedding effect. This can get to be a big bookkeeping problem and can create a lot of work. Again the COOP MONITOR System has solved this problem.

f. NO PROVISIONS FOR MIXED BINARY / BCD INPUT PROGRAMS; Fortran 60 does not provide any method for inputting a binary program or subroutine into a stacked monitor run, if it is not already a part of the library. Thus no mixed input to the system is allowed. This requires frequent recompilation of subroutines and programs which are not incorporated onto the library tape. Again the COOP MONITOR / FORTRAN 62 System provides the solution.

g. LIMITED "DE-BUGGING" AIDS; The only automatic de-bugging aids incorporated into the Fortran 60 System are the compiler and arithmetic error print-outs. The selectable aids consist of a "Map Language" (see ref. #21, pg #102) listing of the compiled program, and a few dump routines which were never very effective. A magnitude improvement has been made by the COOP MONITOR System towards providing de-bugging facilities, both automatic and optional.

h. UNDESIRABLE INTERMEDIATE LANGUAGE FORMAT; The intermediate language of the Fortran 60 compiler is "Map Language". This form of computer coding can become familiar, but only a small percentage of the general users of the computer facility were ever motivated to use it. Three "languages" for coding a single compiler seems to be more than should be required. Successful utilization of the Fortran 60 System requires a knowledge of the fortran language, CDC Symbolic format, and of the intermediate language, "Map". The Fortran 62 system is a two language system and is quite acceptable except for the exclussion of the line for line inter-mix capability between fortran and symbolic coding.

i. POOR INPUT / OUTPUT FLEXIBILITY UNDER MONITOR CONTROL; The Fortran 60 System originally had a very weak tape assignment system. It would assign tapes for scratch when the units weren't even loaded. This was corrected by the authors for the school's facility. Another deficiency is the inability of the monitor to provide multiple input / output BCD units. This is desired in many programs, for instance, when cumulative data is being generated and processed over a long period, or when special table lists are to be formed by a program, etc.

j. SLOW CARD READ / PUNCH ABILITY; The school's "On-Line" card facility is a CDC 1609 system which is capable of operating at either 50 or 100 cards per minute. The Fortran 60 system provided operation only at the 50 card per minute rate. COOP MONITOR will run at the maximum speed of 100 cards per minute and compiles as it reads if the card reader is being used for input. This rate is still too slow for a general usage on-line input medium, hence it is used only as a back-up system for the IBM 1401 System which normally processes the card to tape conversion "off-line".

3.0 COOP MONITOR SYSTEM

The COOP MONITOR SYSTEM was developed to allow a computer facility the ability to operate with only one "library" tape and yet effectively process any type of input programming or source language. This would eliminate the need to sort incoming jobs into separate groups to be run under individual library tapes. The advantage of a single library is readily apparent when operation from a remote station is anticipated, where the operator is physically separated from the main computer and unable to change the current system library tape.

To increase COOP MONITOR'S flexability it is organized into two basic levels of control. At the highest level is the Master Control System (MCS), which maintains the overall system coordination and supervision. At the next level is the Secondary Control System (SCS), and there may be any number of these available on the library. Each SCS is designed to perform a particular job or combination of jobs depending on the requirements of the computer facility.

A brief description will now be given covering the basic organization and operation of COOP MONITOR, for a more detailed description refer to ref.10.

3.1 Master Control System

To accomplish the desired system supervision, MCS is organized into nine functional subroutines and the Bootstrap loader (BOOT), see figure 3. BOOT and the first eight subroutines make up the "permanent" resident, with the memory space occupied by the Job Sequencer (6000 cells) released for use each time control is given to the Secondary Control System. After the SCS has finished using the subroutine

"Loader" the memory space it occupied may also be released for use by the current program. This procedure allows MCS to be very large and complex (13500 cells) and yet not unduly penalize an input program in memory space requirements. The basic functions of each subroutine are as follows:

a. BOOT; Contains the Available Equipment Table (AET), which enables MCS to determine the input/output units available to the computer and their intended use. This routine will load on option either MCS or the system recovery dump routine "EXTREC". BOOT also contains the MCS flags to store current job information to allow intra-job continuity.

b. CLOCK; Allows use of the computer real time clock to set a time limit on the current job. This routine is available to the programmer to set one additional time limit and also may be used to determine elapsed time.

c. MEMREC; Maintains a record of the limits on the one contiguous block of available memory between resident and any programs loaded into high core.

d. OPCON; All communication between the computer operator and MCS or SCS is thru this routine. This input or output is normally via the console typewriter.

e. INTERRUPT; This routine has three sections, SELECT, DETECT, and REMOVE. These allow for the selection and detection, or the release of any of the internal computer interrupts or on channels 1 to 6 inactive.

f. READ/WRITE; This subroutine controls all input/output operations of the computer. Provides protection from illegal use of any unit and prevents interference between units on the same channel.

g. ERROR; Used in the event of user program failure or the detection of illegal operation by MCS, entry into this subroutine will terminate the current job. ERROR will output the current contents of all the console registers (on the standard output medium) and the lower address of cell 7, and then determine if the user desires a memory dump.

h. RW1607; The driver for the magnetic tape units and the only driver contained within MCS. This subroutine is the only place where tape units are selected and activated, except in BOOT for loading MCS or EXTREC.

i. LOADER; Loads all relocatable binary programs or subroutines either from the system library or user provided input medium. This subroutine packs programs into high core memory with common block storage assigned to low core just following "LOADER".

j. JOB SEQUENCER; Used between input jobs to set program limits, determine and load input/output drivers requested by the user, and to call and transfer control to the desired Secondary Control System (SCS). This subroutine also contains the programming to process any computer operator statements received via "OPCON".

These functional blocks are closed subroutines with multiple entry points depending on the particular function desired. These entry points are available to all routines and must be used whenever one of the above operations is necessary. This also includes other blocks within MCS, example, The JOB SEQUENCER

BLOCK DIAGRAM COOP MONITOR

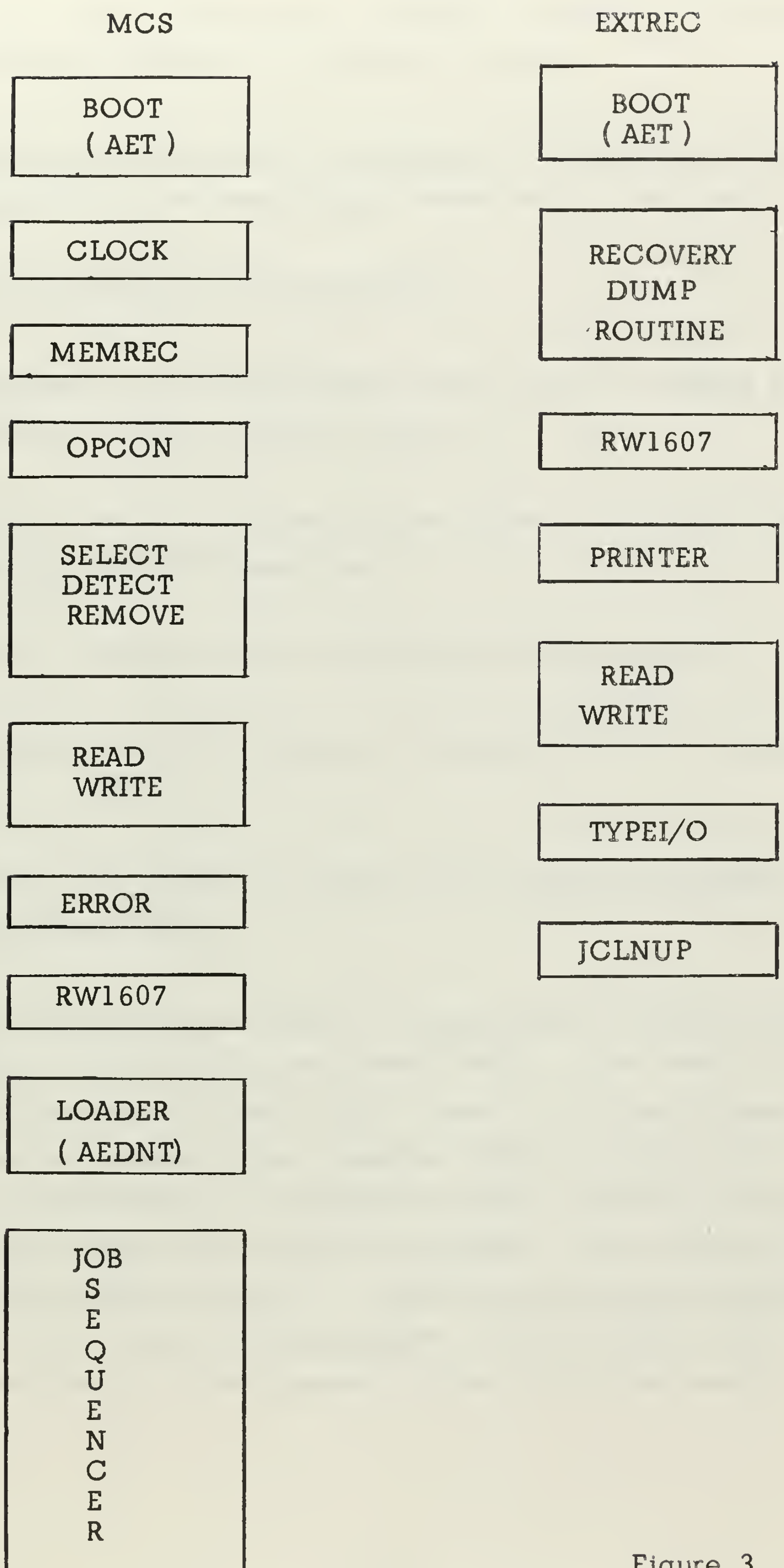


Figure 3

must use LOADER to make a library call, and LOADER in turn must use RW1607 to actuate and read the magnetic tape unit. These subroutines operating together as a Master Control System provide the following features:

a. Automatic, variable job sequencing, including accounting records and time and output line limits set for each job.

b. Operator-Machine communication.

c. Assignment of all input/output units and the loading of the necessary drivers for these units.

d. Single linkage to all input/output drivers to protect them from interference and illegal use.

e. Flexible linkage to the CDC 1604 interrupt features.

f. Automatic recovery features in the event of "user" program failure.

g. Calling and tranfer of control to any desired Secondary Control System (SCS).

The assignment and control of input/output equipment by the MCS is accomplished thru three tables. The first, the Available Equipment Table (AET), lists all the input/output equipment connected to the computer. Some of these I/O units are designated as "standard" (SIO), and are assumed to be always available for use by the system. The entries in the AET (one for each I/O unit), contain the following information: Allowed use, current job assignment, standard unit or not, equipment type, and the location of the I/O driver name. For

a complete description of the AET entry format see ref.10. This table is set for each installation and is changed only as equipment status changes. A listing of the current AET is shown in figure 6c.

The second, the Available Equipment Driver Name Table (AEDNT), lists the name and entry point location for each I/O driver subroutine for controlling the units listed in the AET. The entries are two words long. The first word contains the entry point locations of the routine if it is in memory, or an exit to MCS if not in memory, see section 3.5 part D for an example of an AEDNT entry.

The third, the Running Hardware Table (RHT), lists the input/output assignments of units for the current job only. The entries are AET entries with the address of the proper driver entry point inserted and the allowed use set. Logical unit numbers are used as an index to this table, logical numbers 1-49 are available to the programmer, 0 is reserved for the system library tape and 50-63 for standard units.

3.2 Secondary Control Systems

The great flexibility possible with the COOP MONITOR is in the use of a Secondary Control System (SCS) to control the processing of a specific job. There can be any number of Secondary Conrol Systems which may be written by each computer facility to handle the specialized needs of its users. Thus for use at the Postgraduate School the standard "stacked job" daily production runs would be controlled by one SCS, and a satellite digital controller simulation by a different SCS, and a real time radar intercept problem by a third SCS. All of these SCS would be placed on the standard library tape and available within a few seconds after a particular one is called from the library. No modification is needed in the standard COOP MONITOR

to use a different SCS. The name of the desired SCS is given to the JOB SEQUENCER in MCS at the begining of each job and this name will go to LOADER and the SCS will be loaded from the system library.

There are two SCS provided in the present version of COOP MONITOR, these are called "COOP" and "LIBEDIT". A brief description of each is given to illustrate the technique of tailoring a SCS to do a specific problem. The first, COOP, is responsible for the intra-job sequencing necessary to compile and execute an input job, ie; the calling of compilers or assemblers, transferring binary card images to a "load and go" tape, calling LOADER to load the "load and go" tape and finally, execute the loaded program. The present version of COOP can call two compilers, FORTRAN-62 and CODAP1 (actually an assembler), but COOP can be modified to accept any number of compiler languages. COOP also contains internal routines for user controled binary deck manipulation, loading and execution.

The second, LIBEDIT, has two subroutines, Edit Library Tape (ELT) and Prepare Library Tape (PLT). Edit Library Tape is used for minor changes in the system library such as a deletion or addition to the subroutine file or within MCS and EXTREC. This secondary control system makes a copy of the present library tape upto the point of the desired change and then inserts or deletes the proper information. For a detailed description of the steps necessary in a complete LIBEDIT, see appendix I and ref.17. Prepare Library Tape is used for major changes to the system library. The user must now supply all the information necessary to produce a new version of the system library tape, nothing is copied from the old library tape. LIBEDIT does not provide any means of verifying the portions of the new library tape that were not changed.

3.3 System Operation

A brief description of the operation of MCS can now be given, for a more detailed description see ref. 10. The first record of the library tape, BOOT, see figure 4, is read into the computer by manually selecting and activating the proper magnetic tape unit. BOOT is then executed at cell #2, see figure 6, and will verify the AET table and then skip over the next record on the library tape, EXTREC, and load MCS, see figure 4. Control is now given to MCS which determines the standard input/output units (SIO), loads the necessary drivers for those units if they are not in memory, fills the unused memory space with a jump to ERROR instruction to trap user program failures, and then notifies the computer operator the system is ready to accept job assignments. The operator then either signals MCS to alter the AET or SIO assignments or to begin processing the "stacked job" on the standard input. When signalled to begin processing, MCS reads the control card from the standard input, logs the first job on the standard outputs (list and punch tapes and the console typewriter), and sets the time and output line limits for the current job, the recovery key is stored in BOOT. The input/output units needed, in addition to the standard units, by the incoming job are determined and assigned and if the proper drivers are not already in memory they are called and loaded. MCS then releases the memory space occupied by the non-permanent section of MCS (Job Sequencer) for use by the SCS or the input program. The desired secondary control system is determined and loaded into memory and MCS then transfers control to this SCS, see figure 5. When the SCS has finished processing the current job, control is returned to BOOT with an indication for a "normal" or "abnormal" job termination. For a "normal" termination BOOT reloads MCS

COOP MONITOR LIBRARY TAPE FORMAT

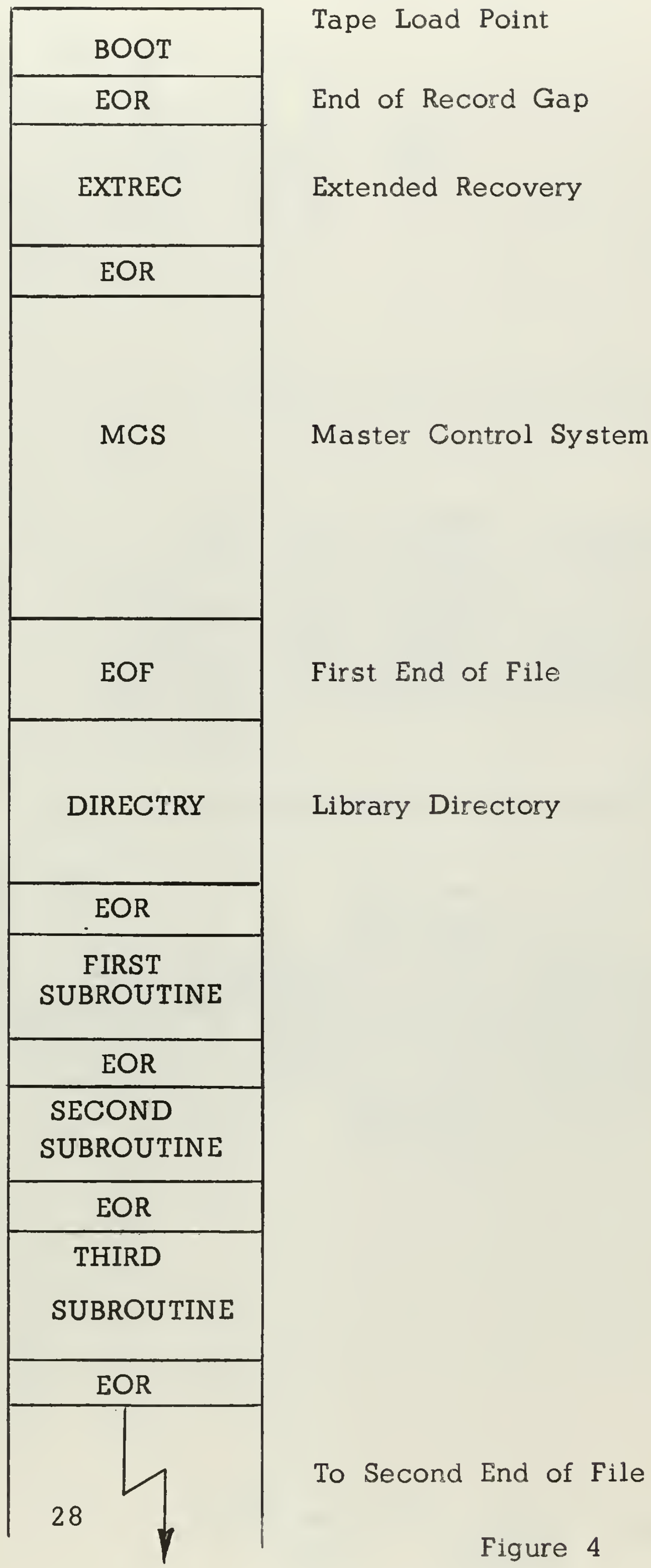
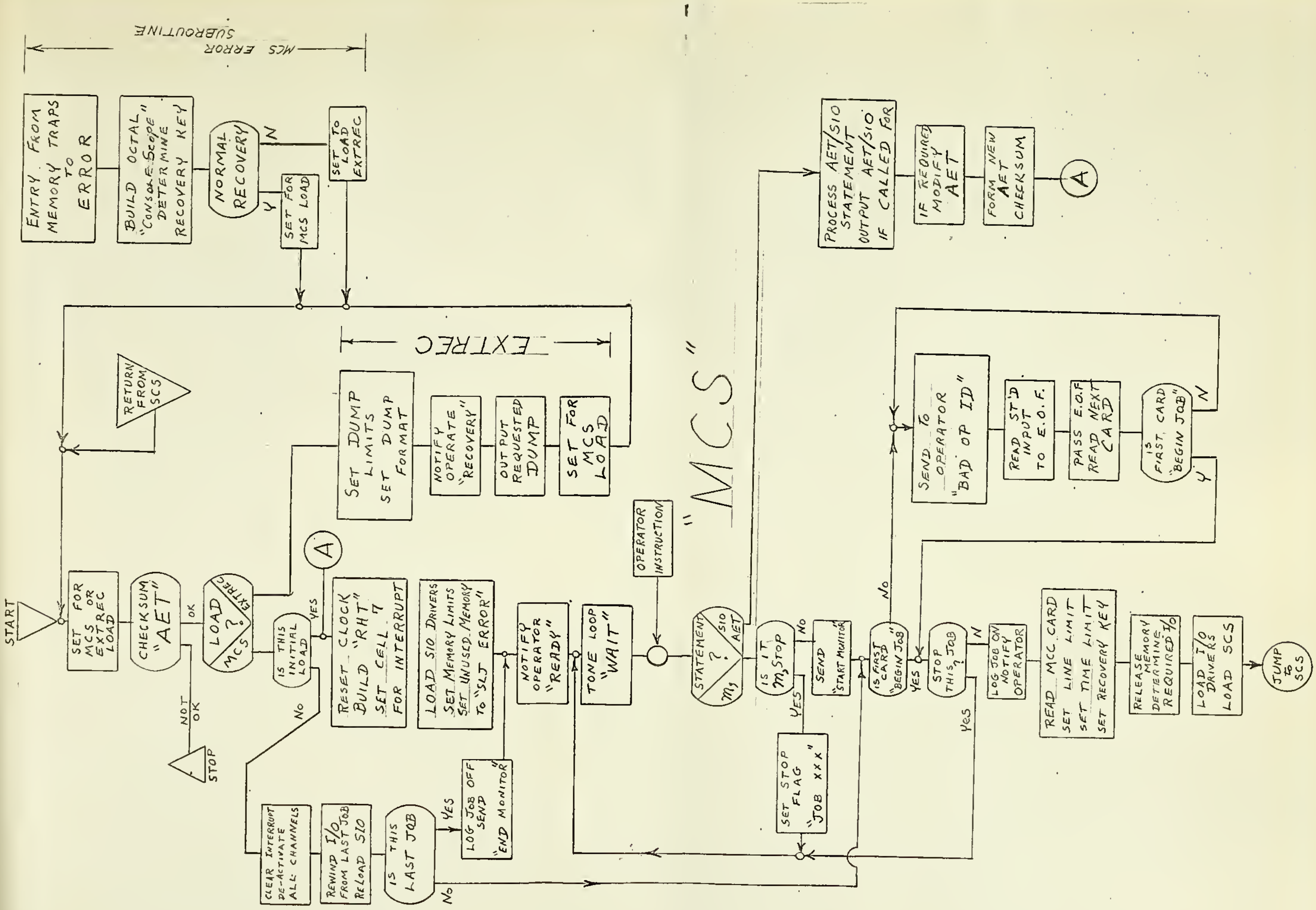


Figure 4



COOP MONITOR SYSTEM MCS
FLOW DIAGRAM
Figure 5

and if there are more jobs on the standard input, the cycle is repeated. For a "abnormal" (error) termination a "Console Scoop" (the contents of all the console registers) is prepared and sent to the standard output tape to aid the programmer in debugging efforts. The recovery key, set by the user at the start of the job, is examined to determine of a memory dump is desired, if not control is given back to BOOT for a MCS reload and the process continues as before. When a memory dump is desired control is returned to BOOT for a EXTREC load, see figure 6. Extended recovery then provides the desired memory dump on the standard output tape and returns to BOOT for a MCS reload. Again if there are more jobs on the standard input tape MCS will start the sequence over, otherwise it will terminate this run and notify the computer operator.

3.4 System's Characteristics

Once over the initial shock of working on a system of this size, the next effort was to consider COOP MONITOR'S good and bad characteristics when the special requirements of the Postgraduate School computer center were included in the system. These special requirements included the daily "stacked job" production runs of short duration, longer runs by the students during the evening, the increased use of the satellite capability of the schools computers, and the addition of a sophisticated digital display unit (Data Display Inc. DD65) as a remote computer input/output device. In this light the COOP MONITOR was determined to have the following major advantages and disadvantages:

3.4.1 Avantages

1. The system can handle stacked input jobs written for multiple compiler languages. The present version includes Fortran-62 and Codapl and the addition of the Neliac compiler and the Scrap assembler is possible.

2. Operates with multiple secondary control systems each specifically designed for a job. Present system has two, COOP and LIBEDIT and others may be added to process satellite and remote display problems.

3. Automatic, programmer controlled, debugging aids such as the "console scoop", provided in the event of program failure and the "snap" feature for those that do not fail but also do not produce correct results.

4. Automatic system recovery in the event of failure by the input program.

5. All input/output is thru one routine, therefore it is very difficult for an input program to illegally use any I/O unit. Interference between units is also minimized.

6. COOP can accept mixed, binary and source language, input programs.

7. Magnetic tape driver routine uses variable block read and write for maximum speed when controlling the system library tape. All read/write is buffered, with parity and length checking.

8. Variable standard input/output units are allowed and these can be changed before each job.

9. Multiple input/output units for each job are allowed up to the maximum available to the computer.

10. The system is capable of handling very large input programs as MCS releases memory and the compiler used is over written when the program is loaded for execution. For programs that are still too large, segmenting and overlaying are provided.

11. The compiler used, Fortran-62, has special features all its own; easy to read intermediate language (Codapl), buffer operation for input/output, and single library subroutine call for each program.

12. Compiler is reloaded for each job thus assuring a clean start.

13. The system will accept Fortran-63 when it is available.

3.4.2 Disadvantages

1. The system is very large (13500 cells) and complex, making it difficult to gain the understanding necessary to perform any system modifications.

2. Many complex (at first) control cards are necessary to process each input job.

3. Provides an unused and unsuppressable accounting information output on the paper tape punch.

4. Normal system operation requires a large number of standard input/output units to be operating. Four magnetic tape units (library, punch, input, and output), the paper tape punch for system accounting, and the console typewriter are required to satisfy the "standard" I/O requirements.

5. Inability of the computer operator to add or delete a standard input/output unit (the type of I/O unit can be changed).

6. Step by step operation by the computer operator via the console typewriter is not possible.

7. The interrupt schedule is not compatable with a real time problem solution in a micro-second time sharing mode, due to the frequent use of interrupt lockout. No provision is made for operation from a remote (satellite) station.

8. No programmed restart available for use by non-autoload CDC 1604 computers (the autoload must be simulated by manually performing the required instructions).

9. No operator service routines are available such as call, copy, transfer, verify, etc.

10. Program errors are sent only to the standard output tape requiring the user to list this tape before determining any errors.

11. The system would not output/input on the CDC 1609 card punch/read unit available at the computer facility.

3.5 Alterations To Coop Monitor System

After a basic understanding of the Coop Monitor System was obtained, it became apparent some modifications would be required before the system would be acceptable for operation at the Postgraduate School's computer facility.

The first modification attempted was the alteration and corrections needed in the cardread and cardpunch drivers to allow operation with the CDC 1609 card read/punch unit. In addition to the corrections, it was also necessary to rewire the unit's plugboard to make the read/punch format compatible with the Coop Monitor. These read/punch routines are an improvement in speed to 100 cards per minute vice the 50 cards per minute available with Fortran-60. Once the drivers were corrected, they were recompiled and the binary versions

were added to the system library tape using the secondary control system "LIBEDIT". For a complete description of the LIBEDIT procedure, and the input job format see appendix I. The correction of these subroutines provided a library tape more suited to the needs of the school computer center but still left some major deficiencies in the system that would prevent convenient operation. These were the following:

a. The unsuppresable accounting medium being output on the paper tape punch, requiring the punch to be selected at all times. This made the paper punch unavailable to the user as an output device.

b. No provision for a programmed restart for operation on a non-autoload computer (CDC 1604). In the event of MCS failure a manual "bootstrap" is required.

c. Error messages from MCS "LOADER" are not available to the user except by listing the standard output medium.

d. No provision for handling operation from a remote station.

The correction of these deficiencies all had one thing in common, they would all involve changes within the structure of MCS. Many early failures soon made it apparent changes in MCS could not be made without a complete understanding of the internal organization of MCS, and a positive knowledge of the operation of LIBEDIT. After these two programs were more thoroughly understood, the modifications resulted in the successful production of a new library tape providing these new features:

a. Accounting medium suppressed, the paper tape punch is not selected unless the operator intends to use it as an output medium.

b. A programmed restart is available, at cell #30, and this will simulate the "autoload" feature of the CDC 1604A except for the initial load.

c. All error messages from MCS "LOADER" are now also output on the comment to the operator medium, normally the console typewriter.

d. All linkages necessary (AET and AEDNT entries) for the calling and execution of a driver subroutine for the remote display (DD65) are now in MCS. Space required for this driver is reserved (1000 cells) within the "permanent" section of MCS just prior to LOADER.

These modifications now provide a library tape that should be much more convenient for the computer center to use and at the same time provide a system that will readily accept experimental drivers and subroutines for operation from the remote station. The detailed explanations and coding involved in these modifications are shown in the following sub-sections.

A. Modifications to BOOT

The postgraduate schools computer (CDC 1604) is a non autoload machine and thus requires a manual selection and activation to read the library tape. The COOP MONITOR uses the autoload feature anytime there is a failure of the automatic recovery routine. To avoid the necessity of this manual "bootstrap" each time this may occur a simulated autoload was placed into BOOT starting at cell #30. This allows an "autoload" restart when needed. At the same time the standard input/output assignments in the Available Equipment Table (AET) were altered to provide the following:

a. Library on channel 3/4, tape unit #1
b. Input on channel 3/4, tape unit #2
c. Available for use, channel 3/4, tape units #3 and #4
d. Output on channel 5/6, tape unit #1
e. Punch on channel 5/6, tape unit #2
f. Scratch 1 and 2 on channel 5/6, tape units #3 and #4

```
START MONITOR RUN.
BEGIN JOB 231
COOP,,,S/2S,20,50000.
CODAP1,1,1,.
1                                                   IDENT      BOOT
       RANGE                 FWA   -   LWA+1
                             00002     14557
       ENTRY POINTS
                             01205       READ*
                             01212      WRITE*
                             00655     SELECT*
                             01140     REMOVE*
                             00743     DETECT*
                             01763      GETCH*
                             01770     CHKSTD*
                             04063     LOADER*
                             04064    RELOCOM*
                             02740     LIBREW*
                             02657    CLBNBCD*
                             02616       EXIT*
                             01777      ERROR*
                             01174    MODIRET*
                             00401      BCDBN*
                             00335      OPCOM*
                             02233     RECRET*
                             02252     RECLIM*
                             00524    FLAGTST*
                             00217     MEMREC*
                             01742        CBF*
                             01743       CBF1*
                             01744       CBF2*
                             01751       CBF7*
                             00714    IOSLECT*
                             01473     MRW600*
                             06342       LOK1*
                             05745     LMSRCH*
                             01121       ILMF*
                             01752        FCH*
                             01034      EXSEN*
                             00167     SETCLK*
                             00076       DATE*
                             00061       SIEOF
                             02732     LIBPOSIT
       NO EXTERNAL SYMBOLS
                             00002              ORG         2
  00002     50   1           00045              ENI     1   CHECKSUM-9             SET X1
            13   0           00057              LAC         CHECKSUM
  00003     50   0           00003              NOP         3
            74   3           40000              EXF     3   40000B                 TERMINATE BUFFER
```

FIGURE 6

```
00004  14 1 00010           ADD   1  8              ACCUMULATE
       55 1 00004           IJP   1  *               CHECKSUM
00005  22 0 00005           AJP   Z  *+1
       75 0 00014           SLJ      CKSUMERR
00006  20 0 00003           STA      3
       74 0 00070           EXF      70B            CLEAR ARITHMETIC FAULTS
00007  75 1 00023           SLJ   1  LOAD           JUMP IF SW 1 IS ON (LOAD 2ND
       75 0 00022           SLJ      PASSONE
00010  50 0 00000 DISASTR*  NOP
       74 0 00101           EXF      101B           REMOVE INT. ON ARITH. FAULT
00011  50 1 00045           ENI   1  CHECKSUM-9     SET X1
       13 0 00057           LAC      CHECKSUM
00012  14 1 00010           ADD   1  8              ACCUMULATE
       55 1 00012           IJP   1  *               CHECKSUM
00013  74 0 00070           EXF   0  70B            CLEAR ARITHMETIC FAULTS
       74 0 00100           EXF   0  100B           SELECT INTERRUPT ON ARITH. F
00014  22 0 00015 CKSUMERR  AJP   Z  LOADON
       76 0 00014           SLS      *              CHECKSUM ERROR STOP
00015  74 0 32011 LOADON    EXF   0  32011B         SELECT READ TAPE 1
       74 0 32005           EXF   0  32005B         REW 1
00016  57 0 00003           SIL   0  3              SET TERMINAL ADDRESS TO ZERO
       74 7 32000 -         EXF   7  32000B         WAIT
00017  23 1 00022           QJP   N  PASSONE
       75 0 00021           SLJ      *+2
00020  50 0 00000           NOP                     TEXAS BOOT
       75 4 01777           RTJ      ERROR*         TEXAS BOOT
00021  74 3 77777           EXF   3  -0             PASS ONE RECORD
       74 7 32000 -         EXF   7  32000B         WAIT
00022  74 3 77777 PASSONE   EXF   3  -0             PASS CNE RECORD
       74 7 32000 -         EXF   7  32000B         WAIT
00023  74 3 00077 LOAD      EXF   3  EXECUTE        LOAD NEXT RECORD
       74 7 32000 -         EXF   7  32000B         WAIT
00024  74 7 32003           EXF   7  32003B         EXIT ON NO PARITY
       75 0 00026           SLJ      *+2
00025  74 3 00000           EXF   3  0              TERMINATE BUFFER
       75 0 00077           SLJ      EXECUTE        JUMP TO LOADED PROGRAM
00026  74 3 00000           EXF   3  0              TERMINATE BUFFER
       76 0 00077           SLS      EXECUTE        STOP ON PARITY, OPTION TO CO
00027  50 0 00000           NOP                     SPARE CELL
       50 0 00000           NOP
00030  74 0 32015           EXF      32015B         AUTO LOAD ENTRY
       74 7 32000 -         EXF   7  32000B         WAIT
00031  74 3 00002 -         EXF   3  2              READ IN BOOT
       74 7 32000 -         EXF   7  32000B         WAIT
00032  75 0 00002           SLJ      2              JUMP TO BOOT
       50 0 00000           NOP
00033  77 7 77777 AET       OCT      -0
       77 7 77777
00034  31 0 13201           31    0  13201B         SYSTEM LIBRARY
```

```
        04  0  06440                 04         AEDNT+1
00035   31  0  23202                 31    0    23202B          STANDARD INPUT
        04  0  06440                 04         AEDNT+1
00036   30  0  53203                 30    0    53203B          AVAILABLE
        04  0  06440                 04         AEDNT+1
00037   30  0  63204                 30    0    63204B          AVAILABLE
        04  0  06440                 04         AEDNT+1
00040   31  1  55201                 31    1    55201B          STANDARD OUTPUT
        04  0  06440                 04         AEDNT+1
00041   31  1  65202                 31    1    65202B          STANDARD PUNCH
        04  0  06440                 04         AEDNT+1
00042   30  2  15203                 30    2    15203B          SCRATCH 1
        04  0  06440                 04         AEDNT+1
00043   30  0  75204                 30    0    75204B          SCRATCH 2
        04  0  06440                 04         AEDNT+1
00044   10  1  01410                 10    1    01410B          1609 PRIMARY READ
        01  0  06442                 01         AEDNT+3
00045   10  0  01420                 10    0    01420B               SECONDARY READ
        01  0  06442                 01         AEDNT+3
00046   20  0  01402                 20    0    01402B          1610-1-PUNCH
        01  0  06444                 01         AEDNT+5
00047   30  0  07100                 30    0    07100B          INPUT FROM DISPLAY
        06  0  06460                 06         AEDNT+17
00050   11  0  01110                 11    0    01110B          TYPEWRITER INPUT COMMENT U
        00  0  06450                 00         AEDNT+9
00051   21  0  01110                 21    0    01110B          TYPEWRITER OUTPUT COMMENT
        00  0  06450                 00         AEDNT+9
00052   20  0  01122                 20    0    01122B          PTP
        03  0  06452                 03         AEDNT+11
00053   10  0  01121                 10    0    01121B          PTR
        03  0  06454                 03         AEDNT+13
00054   21  0  01124                 21    0    01124B          PTP - ACCOUNTING
        03  0  06456                 03         AEDNT+15
00055   30  0  07000                 30    0    07000B          OUTPUT TO DISPLAY
        06  0  06460                 06         AEDNT+17
00056   00  0  00000   AETEND        OCT        0
        00  0  00000
00057                  CHECKSUM      BSS        1
00060   00  0  00000   JSFLAG        OCT        0
        00  0  00000
00061   00  0  00000   SIEOF         OCT        0
        00  0  00000
00062   00  0  00000   LINECNT       OCT        0
        00  0  00000
00063   00  0  00000   JOBXXX        OCT        77
        00  0  00077
00064   00  0  00000   JSTOPX        OCT        0
        00  0  00000
00065   00  0  00000   RDATA         OCT        0
```

1

```
         00  0  00000
00066    00  0  00000   RPROG     OCT         0
         00  0  00000
00067    00  0  00000   RDMPFLG   OCT         0
         00  0  00000
00070    00  0  00000   MARKTIME  OCT         0
         00  0  00000
00071                   LASTOT    BSS         1
00072                   OLDTIME   BSS         1
00073    37  7  77777   TOTIME    OCT         377777777777777
         77  7  77777
00074    00  0  00000    RHT      OCT         0
         00  0  00000
00075    00  0  00000   REMTIME   OCT         0                        IN BOOT
         00  0  00000
00076    00  0  00000   LASTCELL  OCT         0
         00  0  00000
                00076   DATE*     EQU         LASTCELL
                00077   EXECUTE   EQU         LASTCELL+1
```

All references to channel 1/2 magnetic tape units were removed (the school has no units available) and the I/O linkage for the remote display driver was inserted, see figure 6.

These modifications to BOOT altered the location of the begining of the AET and the subroutine EXTREC uses this location as an absolute address. This required recompiling EXTREC with the correct address for the AET and then placing this on the system library tape again using the routine LIBEDIT.

B. Suppression of Accounting Medium

The original version of COOP MONITOR provided for accounting information to be output on the paper tape punch. This output was of unknown format and therefore of no use to the computing center. This did demand the paper punch be selected and prevented the use of the punch as an output device. The suppression of accounting output was accomplished by taking advantage of the READ/WRITE subroutine in MCS. All I/O requests must be thru this routine and this includes any requests for output to the accounting medium, normally the paper punch. Logical number 55 is reserved for the accounting medium and to suppress the output a test for logical 55 is made each time READ/WRITE is entered. If the entry is for any logical number except 55 the request is processed. If the request is for logical 55 a no action exit is made.

This test is made by adding the following programming to the READ/WRITE section of MCS at approximately cell 1225.

```
INA          -55          Test for accounting
AJP    N     *+3          Jump if not accounting
INA          2            Build exit to suppress
SAU          MRW800          accounting output
SLJ          MRW800       Jump to exit
```

This suppresses the accounting output but still allows the paper tape punch to be used as an output medium if desired. Unless the punch is to be used as an additional output unit is need not be selected.

C. Loader Errors to the Operator

Many of the failures of programs to run under the COOP MONITOR result from errors detected by the subroutine LOADER in MCS. These errors cause messages to be written on the standard output medium and this must be listed off-line (unless the standard output is an on-line printer) before the operator can determine the cause of the error. To allow the error message to also be output on the comment-to-operator medium, normally to the typewriter, the following programming was added to the subroutine LOADER in MCS at approximately cell 6274.

```
RTJ     WRITE       Errors to operator
01      53          BCD                 Unit #
03      LERR        Write/Check         FWA
00      LERR+5                          LWA+1
NOP                 Error return
NOP
```

Loader errors are now immediately available to the computer operator as the program is being run to assist in the correction and possible rerun if desired.

D. Linkage for Remote Display

The addition of a I/O subroutine for remote operation of a digital display unit (DD65) requires that proper entry linkages be entered into MCS. This will permit the driver to be called (if not within the MCS) and executed. These linkages are in the Available Equipment Table (AET) and the Available Equipment Driver Name Table (AEDNT). Both of these links

have been provided in the present (modified) version of the library tape. In addition, a reserve area of 1000 cells has been made available within MCS (cells 3060 to 4060) to contain the programming for the display driver.

The AET entries (in BOOT) are shown in figure 6 and the AEDNT entries are located at the end of the subroutine LOADER, at approximately cell 6460 in MCS. These entries are:

```
BCD      DISPLAY
SEV      3070
SLJ      HOWLER
```

where SEV indicates the driver is within MCS
and 3070 is the entry point address of the driver

This link therefore requires the display driver to have its entry point located at cell 3070 to be executed properly. If a new entry address is desired it must be entered into the AEDNT, the AET entry need not be changed.

The final modifications made to the COOP MONITOR system were the addition of two subroutines to the library tape. These subroutines were: 1. Grafplot, to allow a graph of any two designated arrays to be drawn on an incremental plotter, see section 4.1. 2. UCSD, a new Secondary Control System written by the University of California at San Diego, which allows the use of simple control cards for running "stacked job" input for compile and execution.

3.6 Specifications for Further Modifications

The modified version of COOP MONITOR is now ready for the next step in the development of an operating remote station capability. This is the programming and insertion into MCS of a remote station display (DD65) driver, the alteration of

the system interrupt handler (SELECT, REMOVE, DETECT) to allow remote station interrupts and a subroutine to display graphical information on the remote display. The specifications for these three modifications are discussed in the following sub-sections:

A. Remote Display Driver

This subroutine would allow the display to function as the comment-to-operator medium, normally the console typewriter. One of the subroutines for this driver has been completed and is fully described in section 4.2 "line printer simulator". This subroutine will produce a line by line display on the console (DD65), that will move upward with the arrival of each new line, like a typewriter Only the upper half of the tube face should be used for the "line printer" to allow the lower half to be used as a "status board" for computer input or output assignments and any special information for the remote station operator.

To correctly process input/output requests from COOP MONITOR (from READ/WRITE) the remote display driver must accept the standard calling sequence and correctly respond to the parameters specified. The specifications for the standard calling sequence is now given in the COOP MONITOR format:

TITLE: DISPLAY

PURPOSE: To input from or output to the remote station display (DD65) in a format compatible with the COOP MONITOR.

USAGE: Calling Sequence;

```
                ENA          Location interrupt routine
L               RTJ          DISPLAY
                R.M.         E.C.
L+1             F.C.         A
                I            B
L+2                          Alternate Return ( error )
                             E
L+3                          Normal Return
```

R.M.= Recording Mode, 1 if format is BCD 8 char/word
2 if format is 8 typ. char/word
3 if format is 1 typ. char/word

BCD 8 char/word; implies the internal format is BCD with blanks replacing typewriter characters for which there is no BCD equivalent.

8 typ. char/word; implies the internal format is 8 typewriter characters per word.

1 typ. char/word; implies the internal format is 1 typewriter character per word.

E.C.= Equipment Code with format CRXX
C= Channel number (7 for display)
R= 1 for input, 0 for output
X= Not interpreted

I= Interrupt Selection
1= With interrupt, use the address in the A register
0= No interrupt, ignore the address in the A register

F.C.= Function Code explained below.

A, B, E = Detailed under each function code.

Functions: In all cases if a parameter error is encountered E is set equal to 0 and control is transferred to the alternate return. Parameter errors are such things as channel not equal to 7, R not equal to 0 or 1, incorrect function codes, etc. E is always set to reflect the case in which the typewriter (simulated by the display) is left. This has no meaning for the display but the correct response if necessary for COOP MONITOR. The 2^6 bit of E is set to 1 for upper case.

F.C.=1

Starts transmission of data to or from an area specified by the first address (A) and the last address plus 1 (B). In some cases a conversion and/or packing/unpacking operation is required by the recording mode.

For input, R.M.=1 (BCD 8/wd)

Keyboard input with no interrupt on carriage return is selected. Characters are packed eight per word until the area from A to B-1 is filled or carriage return is sensed. If carriage return is sensed fill out the last word with blanks if necessary. Interrupt on carriage return is selected and an exit made with the number of words read in the A register.

R.M =2 (Typ 8/wd)

This mode is the same as R.M.=1, except the BCD code from the display must be converted to typewriter characters.

R.M.=3 (Typ 1/wd)

The characters are read, converted to typewriter code, and stored one per word in area A to B-1. Interrupt on carriage return remains selected.

For output, R.M.=1 (BCD 8/wd)

The information from A to B-1 is packed into the proper format for the display and output. If the message overflows a three line buffer (186 characters) the overflow is lost.

R.M.=2 (Typ 8/wd)

The information from A to B-1 is converted to BCD and packed into the display format and output.

R.M.=3 (Typ 1/wd)

Same as R.M.=2 above.

F.C.=2 Check only

Control is returned with the number of words transmitted by the last read (R=1) or write (R=0) operation. This function if needed to satisfy MCS which assumes some of the transmissions are buffered and therefore it must return to the driver a second time to determine the number of words "buffered".

F.C.=3 Read/Write with checking

Same as the operation for F.C.=1, with the number of words processed entered in the A register before returning.

F.C.=4 Sense Equipment Ready

Determine if the display is in a "ready" status, if it is not ready set E to 1 and use the alternate return. If it is ready set E to indicate the current status for the "case" and use the normal return.

The present COOP MONITOR does not use any of the provisions incorporated for F.C. greater than 4. The driver routine need only check that the function code is within the range 1 to 4. If not set E=0 (parameter error) and use the alternate return.

B. Coop Monitor Interrupt Package

Before any great amount of programming can be done to adapt COOP MONITOR for remote operation, the present interrupt package (Select, Detect, and Remove) must be modified. This subroutine can presently select and sense interrupts on channels 1 thru 6 inactive and all internal interrupts. It cannot select or sense satellite generated interrupts on channels 3/4 or 5/6 via the CDC 1607 magnetic tape units, nor can it select or sense any channel 7 interrupt.

The calling sequence for the interrupt subroutine, see ref. 10, uses the integers 1 thru 12 to set the type of interrupt to be selected and sensed. The integers 1 thru 8 are used for those interrupts to be removed. These calling parameters need to be increased to provide the following additional options.

For Select:

Type Interrupt	Action
13	Select program control for channel 3/4
14	Select program control for channel 5/6
15	Interrupt on keyboard 1 hit (DD65)
16	Interrupt on keyboard 2 hit (DD65)
17	Interrupt on radar target hit (DD65)

For Remove:

To avoid confusion use the same parameters to remove the above selections

Before any of these changes are attempted the precautions necessary for programming an interrupt package, discussed in ref. 13, must be carefully considered.

Along with these modifications to the interrupt subroutine, the main frame of the computer should be modified to allow

computer selection of interrupt lockout. This would avoid the present procedure of selecting interrupt on arithmetic fault and then forcing a fault just to place the computer in lockout mode. There is just such a routine in MCS (RLOKOUT) to perform this function. This takes 20 instructions to accomplish what could be done with one. These modifications would be similar to those described in section 4.4 to provide computer selection of remote indicator lights.

C. Data Display Graph Plot Routine

The incremental graph plotting system has been operational for approximately six months, see section 4.1. A routine to provide this graph plot capability utilizing the Data Display unit (DD65), still needs to be completed. The following specifications and suggestions should provide an outline for incorporating this "Graph Display".

1. Use the author's scaling routine to scale to units per inch.
2. Use this scale and 16 increments per inch vice the 100 per inch used in the incremental system to build a scaled integer array of coordinate points.
3. Output the axis, titling, and labeling data using the standard "Grafplot" technique.
4. Curve drawing requires extensive use of the string capability of the display in order to provide for multiple curve graphs. This is due to the relatively small, 1024 cell 24 bit, memory of the data display.
5. Memory allocation in the DD65 Display should be about as follows:

    a. Vertical and Horizontal Axis, 8 inches long. Use vector size 64/line. Requires 40 cells.

b. Labels, 4 DD65 words/label. 18 labels requires 72 cells.

c. Titles, A minimum of about 200 cells.

d. Curves, Total memory usage of above is 312 cells. This leaves 714 cells for curves. Using the string vector mode this will provide storage for approximately 2500 vectors.

6. Using only the smallest vectors this will provide for approximately 20 traverses of the display tube. Assuming that an average curve traverses the tube 4 times, it appears that 5 curves may be displayed simultaneously.

Besides an on-line graph display routine, another routine which is very desirable would provide an off-line display of the graphs which were output by the CDC 1604 program for "hard copy" incremental plotting.

4.0 SYSTEM ROUTINES

Several system routines were written for both the Fortran 60 System and the Coop Monitor System. Four of these routines, which were developed, shall now be discussed.

4.1 Grafplot Routines

The 1604 Grafplot Routine, see enclouse 3, was written for the CDC 1604 computer. It generates a magnetic tape output in the format required to drive the 160A Grafplot Routine, see enclosure 2. A version of the 160A routine was written for the 160 computer, see enclosure 1. It bypasses the interpolation option in order to operate in the smaller memory of the 160 computer.

This system will produce multiple curved graphs, each curve is limited to a maximum of 900 points. Optional auto-scaling of data points, titling and curve labeling is available. Figure 7 is a general flow diagram of the 1604 Grafplot routine. Copies of the coding for these routines are available from the CDC DATA CENTER, PALO ALTO, CALIFORNIA or from the U.S.N. Postgraduate School Computing Center.

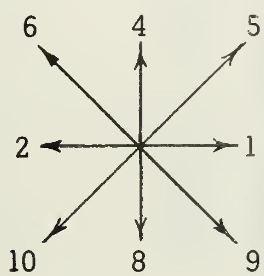
Two original techniques where developed which are of interest. They are the quantized scaling iterative procedure used in the 1604 program and the "decision rule" algorithm for providing "best fit" motion commands to an incremental plotter.

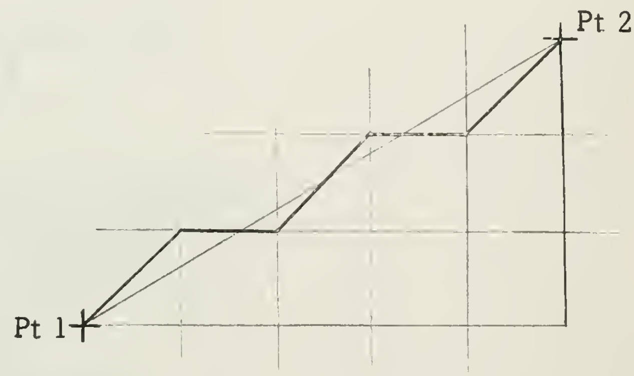
The scaling technique assumes a scale, tests for fit, then iterates to the next quantized scale and test again until the optimum available scale is found.

The two point connector algorithm, "LINE", computes the code string required to move the pen of a digital incremental X,Y plotter from an initial point (X1, Y1) to a terminal point (X2, Y2) by the "best fit" approximation to the straight line between the

points. The permitted elemental pen movement is to an adjacent point in a plane Cartesian point lattice, diagonal moves are permitted. The approximation is "best fit" in the sense that the deviation of the generated line from the true straight line never exceeds one half an increment. This is physically the best fit possible within the movement constraints imposed.

As an example of the LINE program, assume it is required to increment a pen's position with minimum deviation, along a straight line connecting point 1 and point 2. The movement codes for the CalComp Plotter are as follows;





Executing the LINE program, the following values are found;

A = 5

B = 3

NRLONG = 5

NRSHORT = 3

MOSTLY = 1

IBOTH = 5

and the iteration scheme produces the incremental path shown.

Note, in the following fortran program, LINE, a subroutine is required to output the movement codes from the user's particular computer to the incremental plotter. Thus subroutine "PLOT (MOVE)" would output the movement code "MOVE" to the plotter. For the CalComp Plotter the NCODE instructions may be deleted, since the routine is written to require no code conversion for this equipment.

```
      PROGRAM LINE ( X1, Y1, X2, Y2 )
      DIMENSION NCODE ( 10 )
      NCODE ( 1 ) = "user's +X  movement code"
      NCODE ( 2 ) =     "    -X        "        "
      NCODE ( 4 ) =     "    +Y        "        "
      NCODE ( 5 ) =     "   +X+Y       "        "
      NCODE ( 6 ) =     "   -X+Y       "        "
      NCODE ( 8 ) =     "    -Y        "        "
      NCODE ( 9 ) =     "   +X-Y       "        "
      NCODE (10) =      "   -X-Y       "        "
      A = X2 - X1
      B = Y2 - Y1
      IF ( A ) 200,100,100
100   ICODE = 1
      Go To 300
200   A = - A
      ICODE = 2
300   IF ( B ) 500,400,400
400   JCODE = 4
      Go To 600
500   B = - B
      JCODE = 8
600   IF ( A + B ) 1500,1500,700
700   IF ( A - B )  800, 900,900
800   MOSTLY = JCODE
      NRLONG = B
      NRSHORT = A
      Go To 1000
900   MOSTLY = ICODE
      NRLONG = A
      NRSHORT = B
1000  IBOTH = ICODE + JCODE
      LIMIT = NRLONG
      NSWITCH = NRSHORT
      MOSTLY = NCODE ( MOSTLY )
      IBOTH = NCODE ( IBOTH )
1100  IF ( NRLONG - NSWITCH - NSWITCH ) 1200,1400,1400
1200  MOVE = IBOTH
      NSWITCH = NSWITCH - NRLONG + NRSHORT
1300  CALL PLOT ( MOVE )
      LIMIT = LIMIT - 1
      IF ( LIMIT ) 1500,1500,1100
1400  MOVE = MOSTLY
      NSWITCH = NSWITCH + NRSHORT
      Go To 1300
1500  END
      END
```

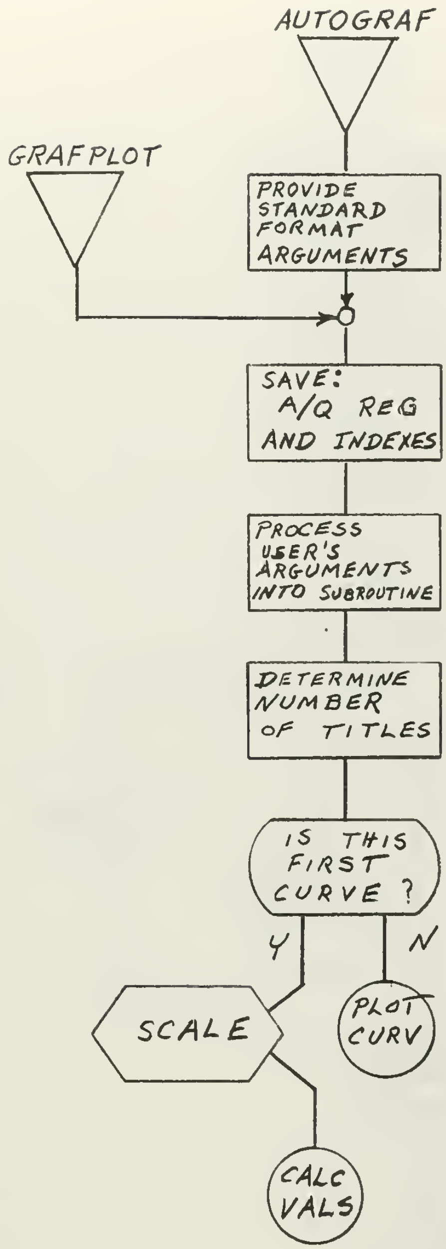

AUTOGRAF
GRAFPLOT
PROVIDE STANDARD FORMAT ARGUMENTS
SAVE: A/Q REG AND INDEXES
PROCESS USER'S ARGUMENTS INTO SUBROUTINE
DETERMINE NUMBER OF TITLES
IS THIS FIRST CURVE ?
Y
N
SCALE
PLOT CURV
CALC VALS

Figure 7a

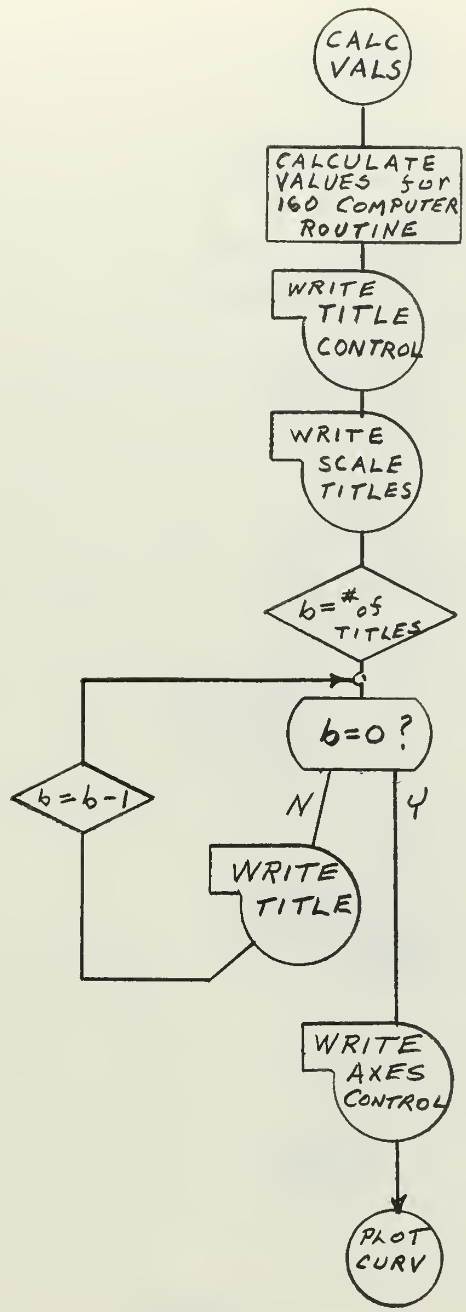

CALC VALS
CALCULATE VALUES for 160 COMPUTER ROUTINE
WRITE TITLE CONTROL
WRITE SCALE TITLES
b=# of TITLES
b=0 ?
N
Y
b=b-1
WRITE TITLE
WRITE AXES CONTROL
PLOT CURV

Figure 7b

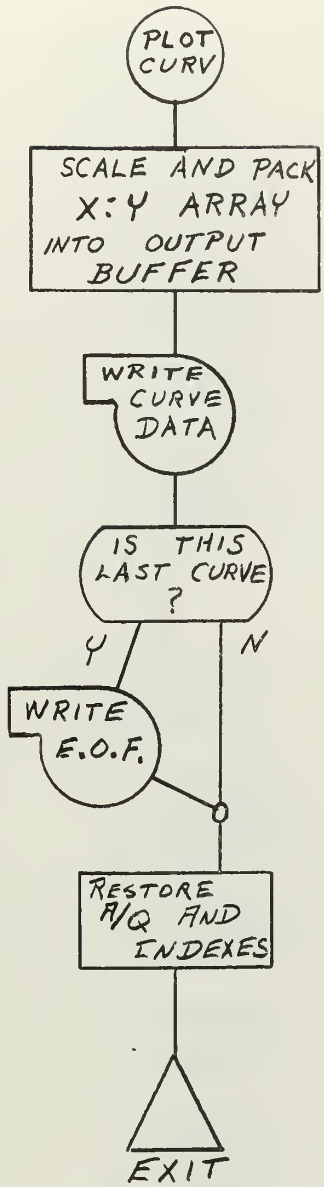

PLOT
CURV
SCALE AND PACK
X:Y ARRAY
INTO OUTPUT
BUFFER
WRITE
CURVE
DATA
IS THIS
LAST CURVE
?
Y
N
WRITE
E.O.F.
RESTORE
A/Q AND
INDEXES
EXIT

Figure 7c

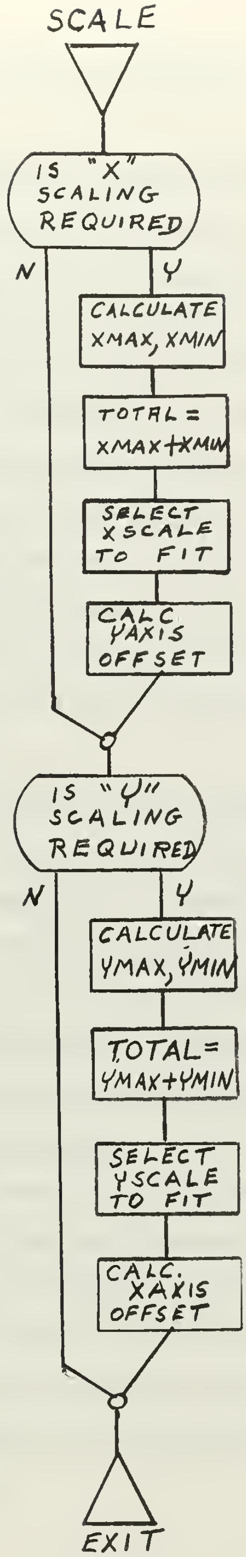

SCALE
IS "X" SCALING REQUIRED
N
Y
CALCULATE XMAX, XMIN
TOTAL = XMAX+XMIN
SELECT XSCALE TO FIT
CALC YAXIS OFFSET
IS "Y" SCALING REQUIRED
N
Y
CALCULATE YMAX, YMIN
TOTAL= YMAX+YMIN
SELECT YSCALE TO FIT
CALC. XAXIS OFFSET
EXIT

Figure 7d

4.2 Data Display "Line Printer Simulator"

The "line printer simulator" program demonstrates a very effective method of providing a continuous page listing ability. The problem was to display one full page of data on the Data Display Incorporated, Model 65, console. The data displayed was to be updated one line at a time by over-writing an old line of data in the DD65's memory. It was desired that this new line entry always occur at the bottom of the page and all other lines would precess up the page and finally disappear. An effective method to provide this listing ability was programmed and added to the Fortran 60 System. An understanding of this program requires a familiarity with the word format used to update the DD65. The DD65 has the following characteristics;

a. It has two keyboards which can be used only as output mediums to a computer. There is no connection or internal logic for providing tube display of a character when it's corresponding key is hit. This is different from a conventional typewriter, which prints it's character automatically when a key is hit. In order to display the character, it must be read by a computer, processed and the appropriate word format must be transmitted back to the display. The display logic then decodes the format of the words transmitted to its memory and displays the appropriate character/characters. There is no provision for read out from the DD65 memory by a computer. The memory serves only to store the data for display upon the cathode ray tubes. The logic cabinet of the display unit contains the circuitry required to scan its memory and display the contents onto the cathode ray tubes.

b. To read from a display keyboard, requires that a sequence of external function codes (see fig. # 9) must be executed to sense keyboard hit, select keyboard for input to the computer, then input one word via channel 7. The BCD code for the key read-in will be the lowest 6 bits for keyboard 1 characters and the lowest 9 bits if keyboard 2 was read. The process of reading the key into the computer releases the key at the DD65 console.

c. Output to the display maybe either characters or vectors. There are three sizes of characters, 32, 64, or 128 per line. There are two sizes of vectors, 64 or 128 per line. The line mentioned is the width of the tube display area, approximately 8.5 inches square.

d. A selection of either character or vector mode, a memory storage address, the X / Y display position, and a tube selection are all data which is conveyed to the display. The word which contains this information is called a designator word, see figure # 8. This designator word can also carry two characters or vectors, depending on the mode selected. Additional characters or vectors can be transmitted after the designator word, if packed in a format called "string word format", see figure # 8. These "string" word characters or vectors will be positioned relative to their preceding designator word. Thus it is the designator word that controls the tube location where the character/vector string will appear. For additional display information, see reference #19.

The line printer routine provides for displaying 32 lines of data. This requires that 32 designator words, each followed by a line of data, be stored in the DD65 memory. Once the data was in the DD65 memory, it was only necessary to selectively transmit new designator words with the appropriate new Y position indicators to move the whole line's position. Thus once the line data has been output, the 1604 is not required to retain an image of the page data in its memory, nor need any time be wasted in re-transmitting redundant information to the display.

The technique employed required that a 32 word designator table be constructed. This table provided memory addresses for data storage from cells 600 thru cell 1777 in the DD65 memory. Note, the DD65 memory cells are only 24 bits long, the disassembly from the 1604 computer's 48 bit word format is automatic in the DD65 logic. Note also that equipment limitations disallow addressing odd numbered memory locations in the DD65. The designator table also provides 32 discrete, equally spaced vertical "Y" axis locations to provide seperation between the lines to be displayed.

The method of up-dating the page displayed requires that all the "Y" locators in the designator words be incremented vertically one line space (20 units). A mask search is then executed to locate the designator word which contains the "Y" locator for the bottom line entry to the page. This "Y" locator is 400. Once found, the designator word is stored in the output buffer. Then the designator table is transmitted to the DD65, thus sweeping all lines vertically one space. The new line is packed into the output buffer. This buffer now contains a

designator word followed by a line of string words. These are now output via channel 7 to the display's memory. Note the channel 7 input / output instructions transmit words, from the 1604 memory in reverse sequence compared to the normal buffer channels. This requires an inverse packing order when packing the buffer for output on channel 7.

This line printer technique has also been incorporated into a typewriter page simulator for the right tube of the display. Both systems are working well.

See appendix IV for the resident coding required for the line printer package. It required only 77 cells including the designator table and a 10 cell output buffer. The designator table is listed in the appendix IV, page # 6.

CHANNEL 7 OUTPUT FORMAT for DD65 DATA DISPLAY

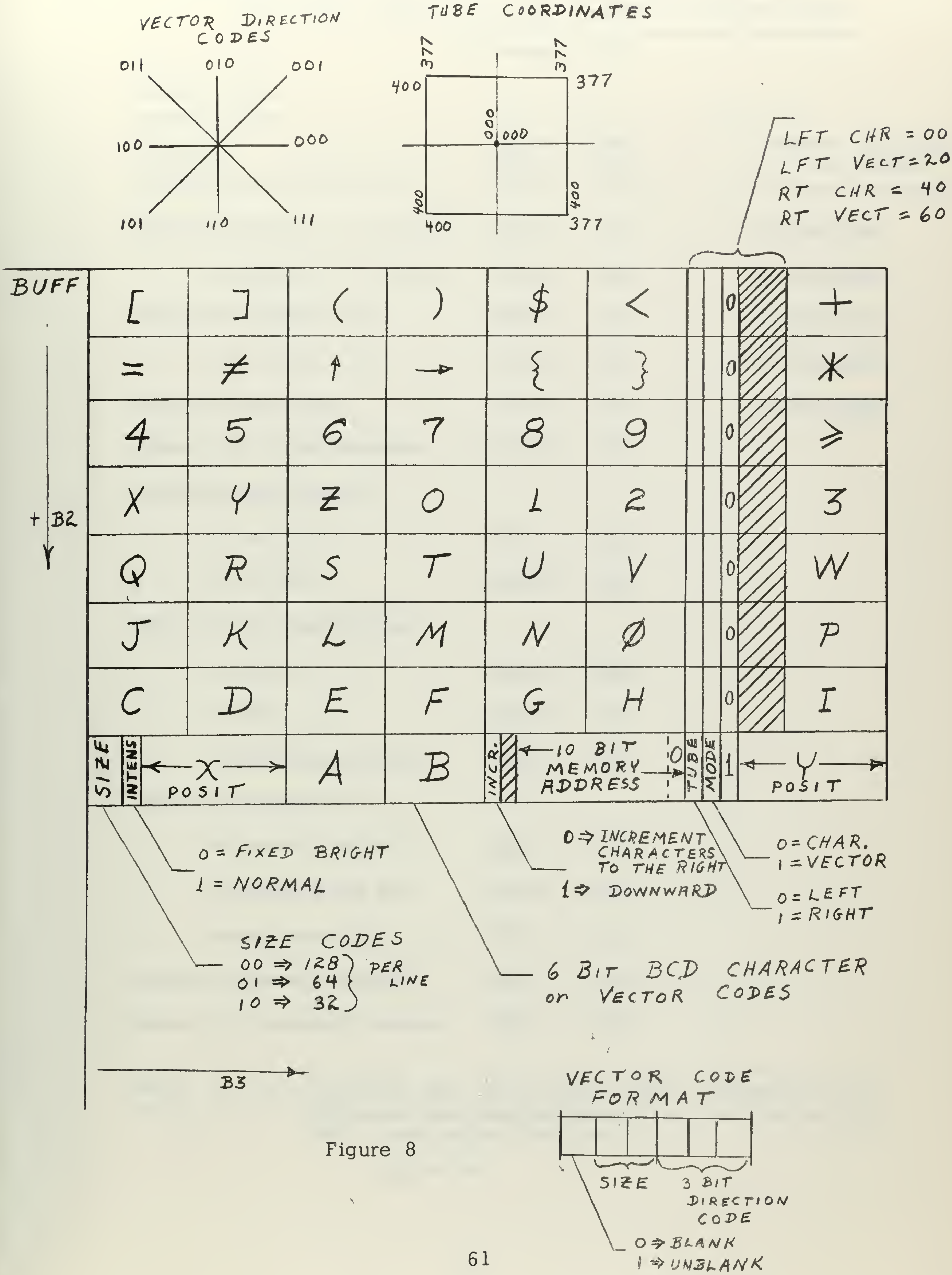


Figure 8

DATA DISPLAY CONSOLE MODEL 65 ''EXTERNAL FUNCTION CODES''

10 December 1962

SELECT CODES

FUNCTION	Select 1604	Code 160	Computer Input Word Bit Format
Select Keyboard 1 for Input	[1]C7140	7140	000000FFFFFF
Keyboard 2 for Input	C7120	7120	000VVVFFFFFF
Select Track Ball ''X''	C7102	7102	000XXXXXXXXX
Track Ball ''Y''	C7104	7104	000YYYYYYYYY
Select Range Switch	C7110	7110	000000000RRR
Select 160 Status Response	[2](C7040)	7040	
Select Memory Update;			
from 1604	C7010	(7010)	
from 160	(C7020)	7020	
Select Radar Target Data;			
to 1604	C7002	(7002)	
to 160	(C7004)	7004	
to Auxiliary Equip.	C7001	7001	
Select Interrupt on;			
Keyboard 1 Key Hit	C7105	(7105)	
Keyboard 2 Key Hit	C7103	(7103)	
Radar Pulse Hit	C7141	(7141)	
Release Interrupt Request	C7111	(7111)	
Remove All Interrupt Selects	C7121	(7121)	

Notes
1. ''C'' Indicates 1604 data channel number. (Normally, C=7)
2. ( ) Indicates code disabled selectively on ''160 or 1604 ONLY'' mode switch position.

Figure 9a

SENSE CODES

CONDITION	1604 Full Exit Sense Code	160 Status Response
Keyboard 1 Hit	C7172	xxx2
Keyboard 2 Hit	C7175	xxx1
Keyboard 1 NOT Hit	C7173	
Keyboard 2 NOT Hit	C7174	
Tab Hit		xx1x
Tab NOT Hit	C7157	
Carriage Return Hit		xxx4
Carriage Return NOT Hit	C7166	
Keyboard 1 Selected		xx4x
Keyboard 2 Selected		4xxx
Keyboard 1 NOT Selected	C7167	
Keyboard 2 NOT Selected	C7037	
NOT DD-65 Interrupt	C7156	
DD-65 from 160 Selected	C7020	2xxx
DD-65 from 1604 Selected	C7010	1xxx
Radar to 160 Selected	C7004	x4xx
Radar to 1604 Selected	C7002	x2xx
Radar to Auxiliary Equipment NOT Selected	C7001	x1xx
Radar Target Present	C7136	xx2x
Radar Target NOT Present	C7137	

Figure 9b

4.3 Merg Sort

The SORT Routine, see appendix III, was written to improve the effeciency and reliability of sorting using the 1604 computer vice the IBM mechanical card sorter. Another motivation was to provide the capability of sorting 120 character records which could not be easily sorted using 80 character cards.

The SORT Routine can sort on variable length column fields from 1 to 120 columns. The present routine divides the field to be sorted into 7 character fields, then multiple entries are made to a subroutine, SORT7, which actually performs the sorting operation. SORT7 divides the computer's memory into three equal bins, ABIN, BBIN, and CBIN. These are each 20,000 octal cells long. SORT7 requires an input tape written in 120 character records with an "End of File Mark" terminating the file to be sorted. Upon entry to SORT7, one of its subroutines, Alsinp, reads 1000 octal cards into ABIN. As each card is read, a sorting key is formed from the column field designated and this key is stored in the cell preceeding the input record image from which it was generated. The key occupies one cell, the record image occupies 17 octal cells, thus each input record requires 20 octal memory cells. Multiply 20 octal by 1000 octal to obtain the arbitrary 20,000 octal bin size which was choosen as the basic block size. Alsinp always checks for an E.O.F. mark and sets a flag to signal the rest of the routine that the last block has been read. After Alsinp has read 1000 octal records or encountered an E.O.F. mark, then an entry is made to a subroutine, Rlhmerg, which performs an internal merg sort by oscillating between ABIN and BBIN, sorting on the keys. The internal merg sort terminates with the sorted block in CBIN. If this was the first block, it is immediately written onto one of the two scratch tapes and Alsinp inputs another block. If this was not the first block, then a subroutine, Hexsort, is entered to perform a merg of the new block

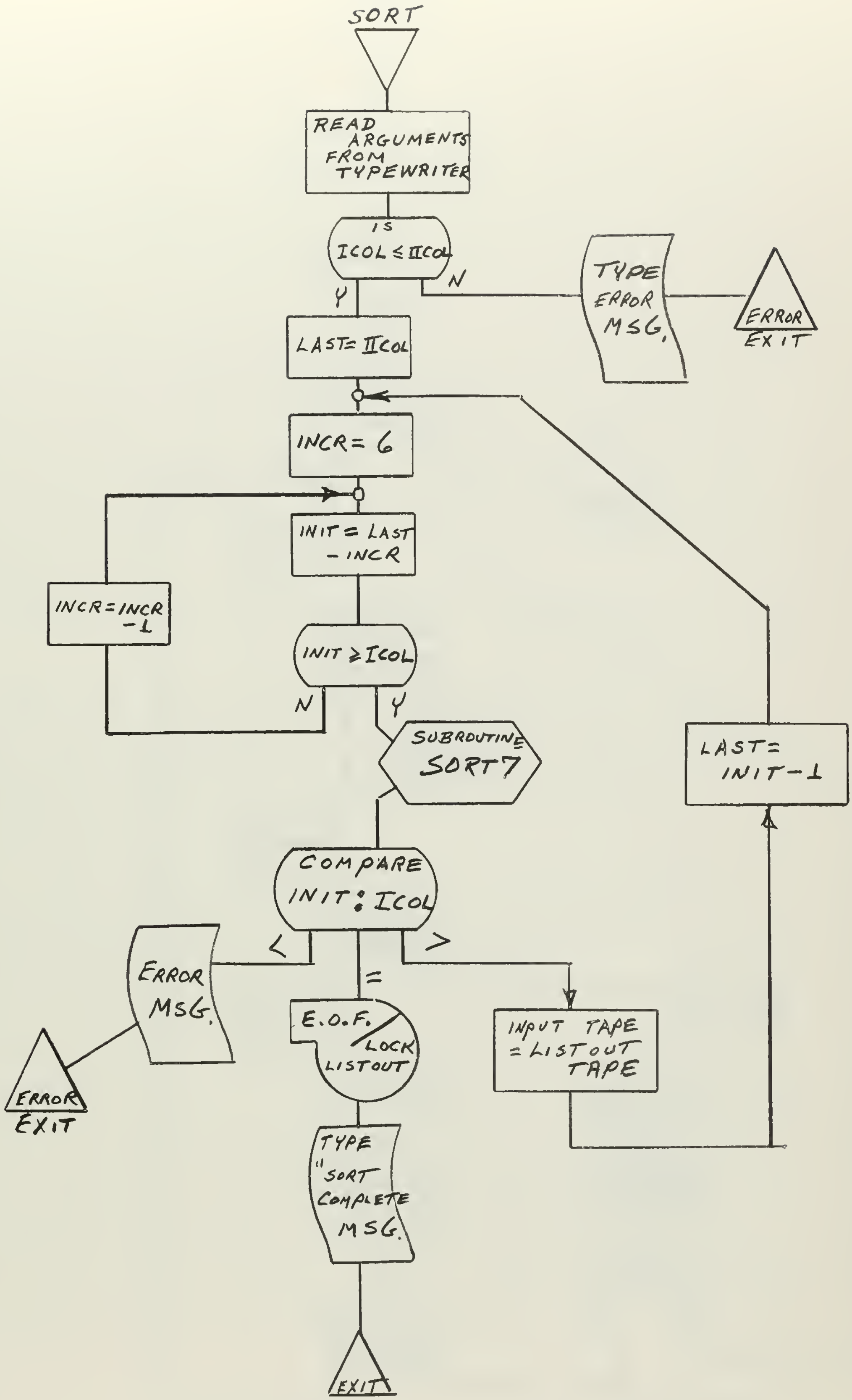

SORT
READ ARGUMENTS FROM TYPEWRITER
IS ICOL ≤ IICOL
Y
N
TYPE ERROR MSG.
ERROR EXIT
LAST= IICOL
INCR= 6
INIT = LAST - INCR
INCR=INCR -1
INIT ≥ ICOL
N
Y
SUBROUTINE SORT7
LAST= INIT-1
COMPARE INIT : ICOL
<
=
>
ERROR MSG.
ERROR EXIT
E.O.F./LOCK LISTOUT
INPUT TAPE = LISTOUT TAPE
TYPE "SORT COMPLETE MSG.
EXIT

Figure 10a

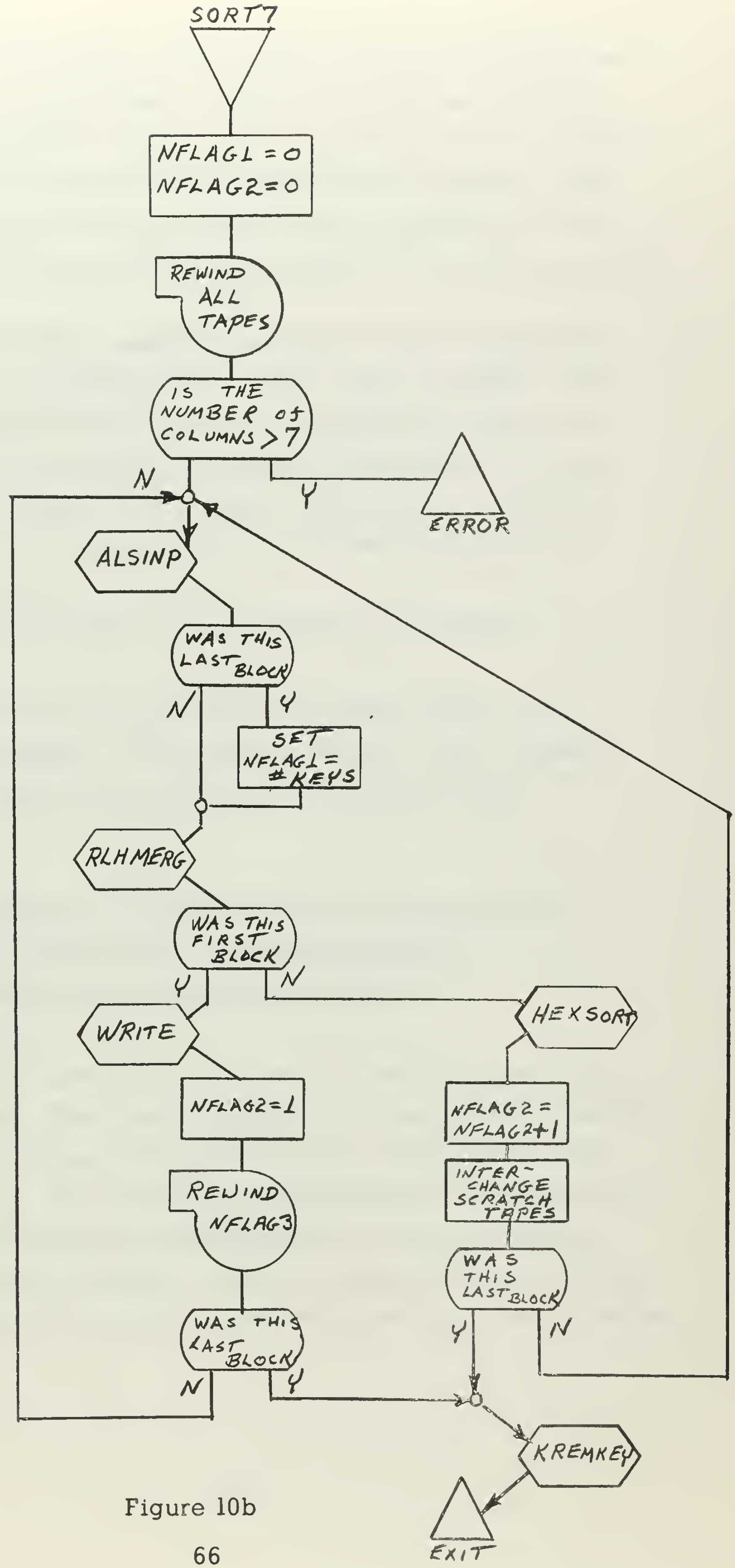

SORT7
NFLAG1=0
NFLAG2=0
REWIND ALL TAPES
IS THE NUMBER of COLUMNS >7
N
Y
ERROR
ALSINP
WAS THIS LAST BLOCK
N
Y
SET NFLAG1= #KEYS
RLHMERG
WAS THIS FIRST BLOCK
Y
N
WRITE
HEXSORT
NFLAG2=1
NFLAG2= NFLAG2+1
INTER-CHANGE SCRATCH TAPES
REWIND NFLAG3
WAS THIS LAST BLOCK
Y
N
WAS THIS LAST BLOCK
N
Y
KREMKEY
EXIT

Figure 10b

into the file of previously sorted blocks which are accumulated externally on a scratch tape. This cycle continues until an E.O.F. is encountered, then after the external merg is complete, the scratch tape is rewound and a subroutine, Kremkey, reads in the ordered blocks from the scratch tape, removes the keys and writes out the output file in an ordered, 120 character record length file.

If additional fields remain to be sorted, this output file is designated the input and another entry is made to SORT7 with the new character field's initial and last column numbers as arguments. This procedure continues until the total sort field is in order and listed on the output. The output is then rewound to lockout and the operator is informed that the job is finished.

Several improvements to this routine are suggested.

a. Build and sort on a two cell key, if large fields are to be sorted frequently. This would provide a better balance between the internal sorting time and the external tape handling time.

b. Provide for sorting on split fields, ie. non-consecutive column fields. This could be provided by forming the sort key piece-wise from specific columns.

c. Use a double entry key / key location table for performing the internal sort. This would eliminate the necessity of carrying the input record image around with the key each time the key order is changed. The sort could be performed by ordering only the keys and maintaining correspondence in the key location table as the keys are sorted. This key location table could then be used to perform the internal ordering of the input record images.

This scheme would improve the internal sorting speed and reliability since it would require fewer internal data transfers.

d. The last and probably the most significant improvement which is indicated, would be to utilize two more scratch tapes. This would improve the sort routine speed by nearly 50%. This is due to the rewind time required by the tape drives and their inability to read in the reverse direction. At present, much time is wasted waiting on the two scratch tapes to rewind in order that the next internal block can be merged with the external ordered file. A suggested method to improve the external sort would be to alternate the merging of the internal block between to sets of scratch tapes similar to the set presently employed. This would increase the rewind time available for each set and thus decrease the idle time mentioned previously. After Hexsort has finished merging the last block, then Kremkey would have to operate differently than at present. Kremkey would have to read one block from the ordered tape of each scratch tape set, then perform a final merg comparison similar to the Hexsort merg routine. Instead of forming an ordered list in memory, this final merg could be written out as the final ordered, 120 character listable output. Before any other modification is considered, this last suggestion should be given priorty "one". At present it remains a gross deficiency against high speed sorting using this routine.

4.4 Satellite System Programming

There are two basic operations necessary to establish an adequate satellite system. These are the ability to exchange data and to selectively execute a pre-stored program when directed by another member of the satellite system. The present installation proposed to couple the CDC 160 to the CDC 1604 Computer. The CDC 160 Computer does not provide an interrupt mode, therefore only the 1604 interrupt mode was available to be employed.

The desirable characteristics of the basic 1604 satellite interrupt program are:

a. Reliability

b. Flexibility

c. Speed

d. Effective Employment of the Communication Flags

e. Minimize Memory Requirements

The problems encountered in designing the basic 1604 interrupt routine shall now be discussed. The 1604 Computer is unable to prevent the 160 Computer from entering the interrupt auxiliary routine which is wired into the 1604. For this reason, a protective "lock-out" scheme was required to prevent interference with the 1604 equipment handling routines. Specifically, there exists a critical time interval between equipment selection and activation during which an interrupt from a satellite station would be disastrous to the main program. The technique develope to prevent this, is as follows: All 1604 equipment handling routines were modified to turn on communication flag I (see ref. # 2) in advance of any equipment selection. Communication flag I is then cleared after the selected equipment is activated. Using this scheme it is

then required that the 160 satellite computer inspect communication flag I prior to executing an interrupt. If flag I is set, then the 160 computer enters a "wait loop" until flag I is cleared by the 1604 Computer. Thus through the use of communication flag I, the 1604 computer is, in effect, capable of "locking out" the 160 satellite computer from an interrupt request. This was a desirable feature not presently provided in the hardware design.

The next problem in the design of the interrupt routine was how to indicate to the 1604 computer, the nature of the task requested by the 160 computer. The method used requires that each interrupt shall immediaty trigger a, 48 bit word, data transfer to the 1604. The format of this word, designated as the "control word", is outlined in detail in figure # 12. After receiving this "control word" the 1604 interprets the operation to be performed. There are four tasks which can be directed by the control word, they are:

1. 1604 INPUT DATA BLOCK
2. 1604 OUTPUT DATA BLOCK
3. PACK ARGUMENT ADDRESSES INTO A SUBROUTINE AND THEN EXECUTE THAT SUBROUTINE.
4. LOAD "A" REGISTER WITH A 21 BIT ARGUMENT FROM THE CONTROL WORD AND THEN RETURN JUMP TO EXECUTE THE SUBROUTINE.

A flow diagram of this 1604 satellite interrupt routine is provided in figure # 11.

One additional problem remains to be discussed, that is storage allocation for the programming required by the satellite system. This was acquired by setting the resident bias level on the Fortran 60 System to 5000 octal, vice the normal 4000.

1604 INTERRUPT ROUTINE FLOW DIAGRAM

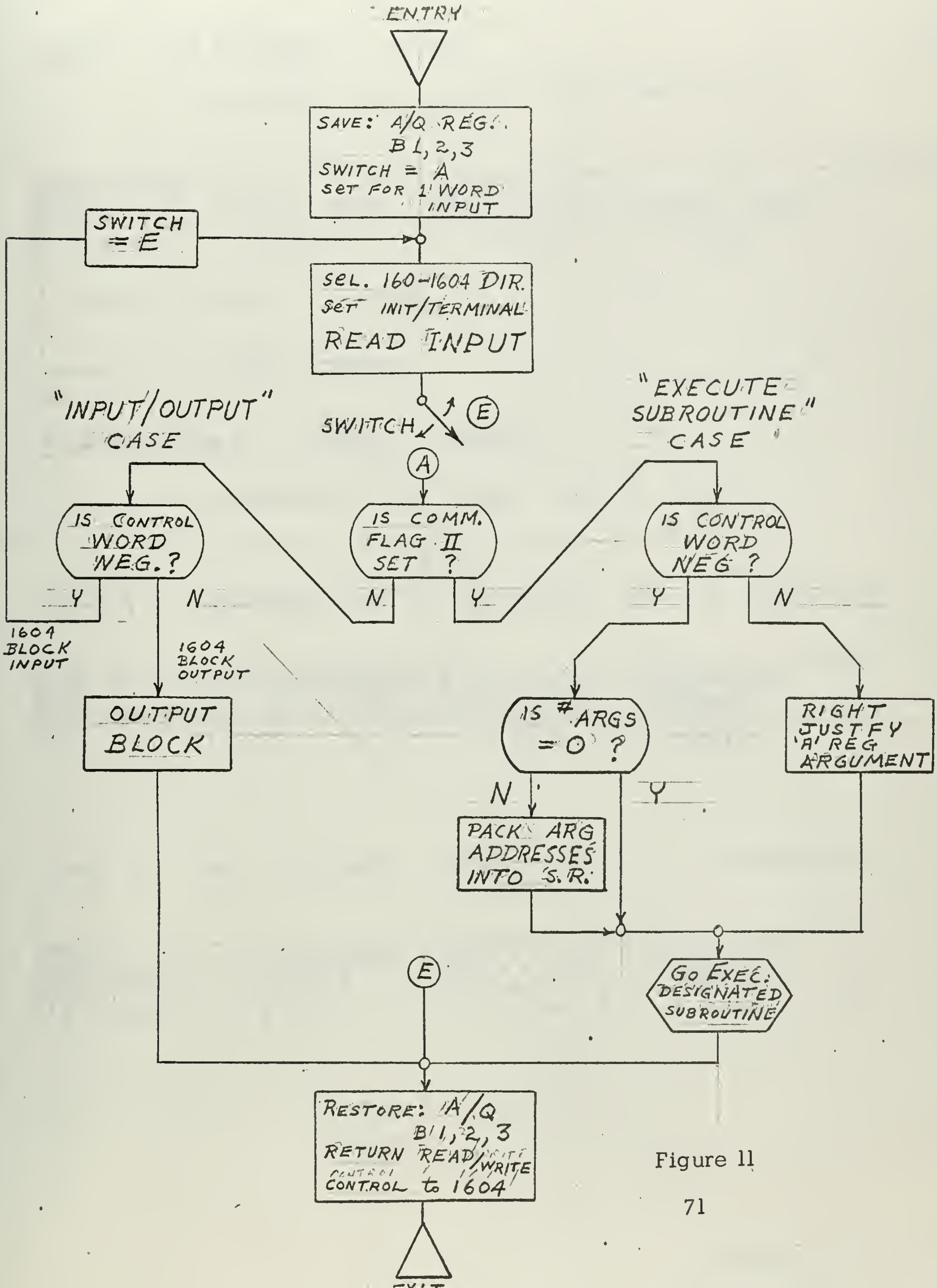
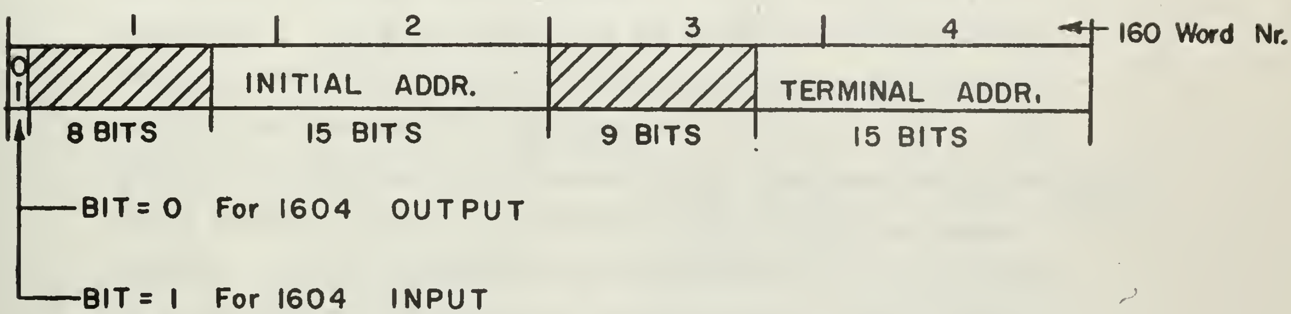


Figure 11

160-1604 SATELLITE
CONTROL WORD FORMAT

DATA TRANSFER MODE

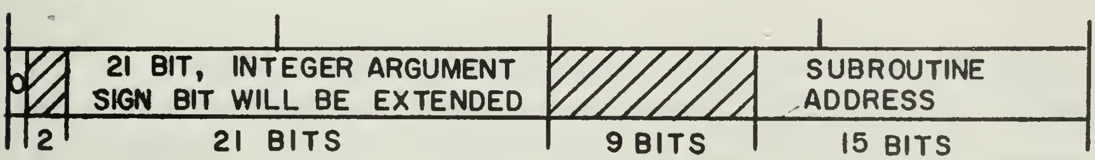
INTERRUPT WITH COMM FLAG II "NOT" SET



SUBROUTINE JUMP MODE

INTERRUPT WITH COMM FLAG II "SET"

TYPE I, ARGUMENT IN "A" REGISTER, RTJ To SUBROUTINE



TYPE II, PACK ARGUMENT ADDRESS, RTJ To SUBROUTINE

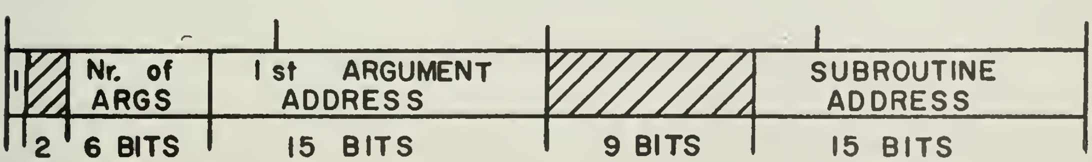


FIGURE 12

This provided the memory space needed to store the satellite programming plus an additional "buffer" area for receiving transient subroutines from the 160 computer. These subroutines may the be executed by an interrupt entry to the 1604 computer via the satellite interrupt system.

The use of the 160 as a satellite station requires that the modified library tape, FORTSAT, be in use by the 1604 computer. Also, the 1604 must be operating under monitor control in order to utilize a remote monitor process routine which was developed by the authors' (see ref. # 22). The physical seperation of the satellite 160 computer station required some means of sensing the above conditions at the remote station. Visual indicators were selected as the best method of implementing the required status sensors. The console of the 160 Computer contains many unused indicator lights, two ot these were selected to be used as status indicators. The first light, designated # 1 or FORTSAT, is a blue-green background field light at the left end of the "P" register. The second light, designated # 2 or MONITOR, is the next blue-green background field light to the right of the # 1 light.

Manual control of these lights at the console of the 1604, was considered an unnecessary burden to the operator. Computer selection would be more convenient and the status indications more current in the reflection of the actual status of the 1604 Computer operations.

To enable computer control of the indicator lights, two new select codes (on - off pairs) for the 1604 were required. As all satellite selects are made in the 1607 Magentic Tape Logic Cabinets, modification of these units was necessary. This modification would allow the 1607 to accept and decode the new indicator light codes. The two codes selected were;

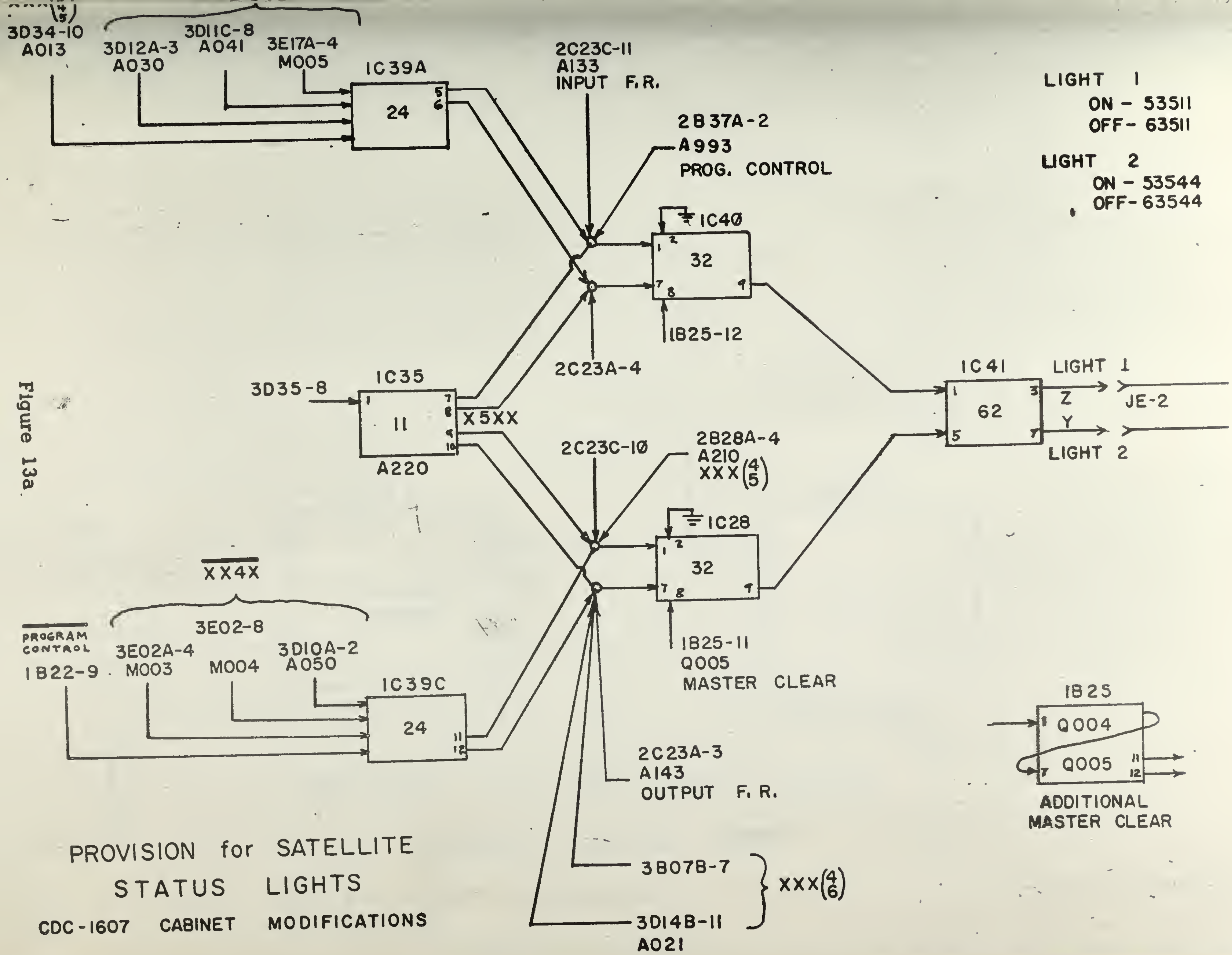
LIGHT # 1	(FORTSAT)	"ON"	53511
		"OFF"	63511
LIGHT # 2	(MONITOR)	"ON"	53544
		"OFF"	63544

The select code format is as follows:

First digit;	Channel number
Second digit;	Cabinet number
Third digit;	Group code, 5 for satellite
Fourth & Fifth;	Condition code

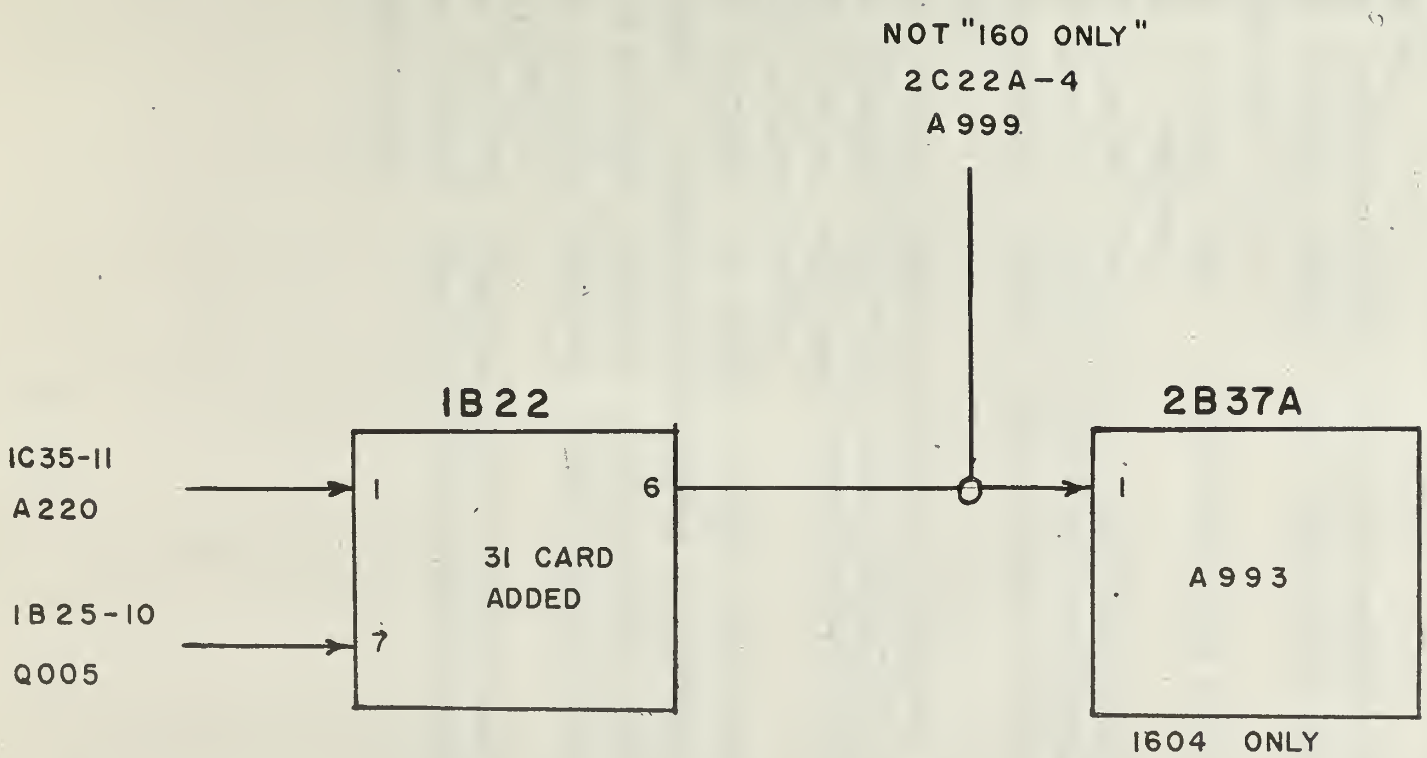
The two codes selected for the indicator lights contain the false cabinet number 3. This was necessary because the 1607 (cabinet # 2) does not uniquely decode the last two digits of any select code. Therefore, to prevent interference with any of the existing codes, a false 3 was used.

To avoid the need for manual selection of "program control" mode of operation for the 1607 Tape Cabinets, when enabling the satellite station, this selection was wired to be controlled by light # 1 and the master clear switch. Initial turn on of light # 1 selects "program control" and the Master Clear disables both lights and removes the program control selection. The logic diagrams for the modificiations made to the 1607 Tape Cabinets are shown by figure # 13. Two relays were added to the 160 to provide switching of the two lights provided.



3D34-10
A013
3D12A-3
A030
3D11C-8
A041
3E17A-4
M005
IC39A
24
2C23C-11
A133
INPUT F.R.
2B37A-2
A993
PROG. CONTROL
LIGHT 1
ON - 53511
OFF - 63511
LIGHT 2
ON - 53544
OFF - 63544
IC40
32
1B25-12
2C23A-4
3D35-8
IC35
11
A220
X5XX
IC41
62
LIGHT 1
Z
Y
JE-2
LIGHT 2
2C23C-10
2B28A-4
A210
XXX(4/5)
IC28
32
XX4X
3E02-8
PROGRAM CONTROL
1B22-9
3E02A-4
M003
M004
3D10A-2
A050
IC39C
24
1B25-11
Q005
MASTER CLEAR
1B25
Q004
Q005
ADDITIONAL MASTER CLEAR
2C23A-3
A143
OUTPUT F. R.
3B07B-7
3D14B-11
A021
XXX(4/6)
PROVISION for SATELLITE
STATUS LIGHTS
CDC-1607 CABINET MODIFICATIONS

Figure 13a



PROVISION for EXF CODE CONTROL

of "PROGRAM CONTROL MODE"

CDC 1604 CABINET MODIFICATION

Figure 13b

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APPENDICES

APPENDIX I

LIBEDIT PROCEDURE

There are two publications available to assist a user of COOP MONITOR in performing a successful library preparation or modification. These are ref.17 and 10. The following was obtained from these two sources together with additional remarks by the authors to aid in the understanding of the procedure.

A. Library Tape Format

The library tape is composed of two files. The first file contains three records in absolute binary format. These are:

a. Bootstrap routine (BOOT)

b. Recovery routine (EXTREC)

c. Master Control routine (MCS)

The second file contains the subroutine library and starts with the "directory". This is followed by the library subroutines each consisting of one record (the system can accept subroutines with more than one record but the present library has none) composed of contiguous <u>relocatable</u> binary card images. Each subroutine is identified and defined in the directory by the following.

A subroutine name

Number of records in the subroutine (normally 1)

Number of common blocks assigned

Names of those common blocks

Length of each common block

Range of the subroutine (FWA and LWA+1)

Number of entry points to the subroutine

Entry point names

Number of external symbols referenced

External symbol names

The order in which the subroutines are identified in the directory must be the same as the order of appearance of the subroutines in the file. The identifying name, each entry point name, each external symbol and each common block name must have the following properties:

a. Eight BCD characters in length, no imbedded blanks

b. Leading character not digital or blank, except common block

The first library subroutine defined in the directory is the Master Control System called "Resident". The length of Resident and all named entry points are defined. External references are not made within the resident program. There are no entries in the directory for the subroutine EXTREC.

The recommended layout of the library subroutine file is:

1. Directory (this _must_ be first)
2. I/O drivers for standard medium
3. All other I/O drivers
4. Secondary Control Systems (SCS)
5. Any other subroutines
6. SNAP (selective dump routine)
7. MAP (produces a memory map of loaded programs)
8. Systems such as FORTRAN, CODAP1, ALGOL, etc.

This layout facilitates one pass loading of library subroutines. The sequence for loading library subroutines will be:

1. I/O drivers for the standard mediums.
2. I/O drivers for the current job.
3. The desired secondary control system.

B. Directory Format

The directory is a set of 8 different types of cards for each subroutine in file 2 of the library tape. These must be ordered in the directory deck in the same sequence as the routines appear

in file 2. Care must be exercised to assure the directory reflects the exact composition of the subroutine file, otherwise errors will result. Each set of directory cards must contain:

1. A card with the subroutine name, left-justitied, in columns 1-8.

2. A card with a 16 digit octal integer, left-justified, in columns 1-16. This has the format:

000KKKKK000RRRRR

where 000 is zero

KKKKK is the number of common blocks required by the subroutine

RRRRR is the number of records the subroutine occupies on the library tape (usually 1)

3. If KKKKK is not zero, there must be a number of cards equal to KKKKK containing the name of each common block. The name is punched, left-justified, in columns 1-8. The card may be blank if no name for the common block is given.

4. If KKKKK is not zero, there must be a number of cards required to define the lengths of the common blocks. These cards contain octal integers separated by commas. The integers specify the length of the common blocks named by the cards in #3 and the lengths must be in the same sequence as the names. Any number of integers, more than zero may appear on a single card. The last integer on the card must be followed by a blank. The number of cards required depends on the number of common blocks and the packing of lengths.

5. A card with a 16 digit octal integer, left-justified, in columns 1-16. This has the format:

PPPFFFFFXXXLLLLL

where PPP is the number of entry points to the subroutine (must not be zero)

FFFFF is the relative first word address of the subroutine (FWA)

XXX is the number of external symbols referenced by the subroutine

LLLLL is the relative last word address plus 1 of the subroutine (LWA+1)

6. The number of cards equal to PPP, each containing an entry point name, left-justified, in columns 1-8. There must be at least one such name.

7. The number of cards required to define the entry point addresses. These cards contain octal integers of 1 to 5 digits separated by commas. The integers specify the relative address of the entry points named on the cards in 6. The entry point addresses must be in the same sequence as their corresponding entry point names.

8. The number of cards equal to XXX in 5. If this is greater than zero, each card just contains the external symbol name, left-justified, in columns 1-8. These external symbol names must be in the same order as they were defined during the assembly or compilation of the subroutine.

The sets of directory cards are preceded by a card with "DIRECTRY" punched in columns 1-8 and followed by a card with "7777777777777777" punched in columns 1-16.

C. Edit Input

The input data for editing a library tape is composed of control cards, directory cards, and program information. The program information is in the form of relocatable binary cards and this binary format must be thoroughly understood by the user to perform a successful LIBEDIT. Appendix III of ref.10 gives a complete description of this binary card format.

The input data must be on the standard input unit along with the required MCS control information ("begin job" and "mcs" cards). The next card of the edit input deck must

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

LIBEDIT INPUT DECK

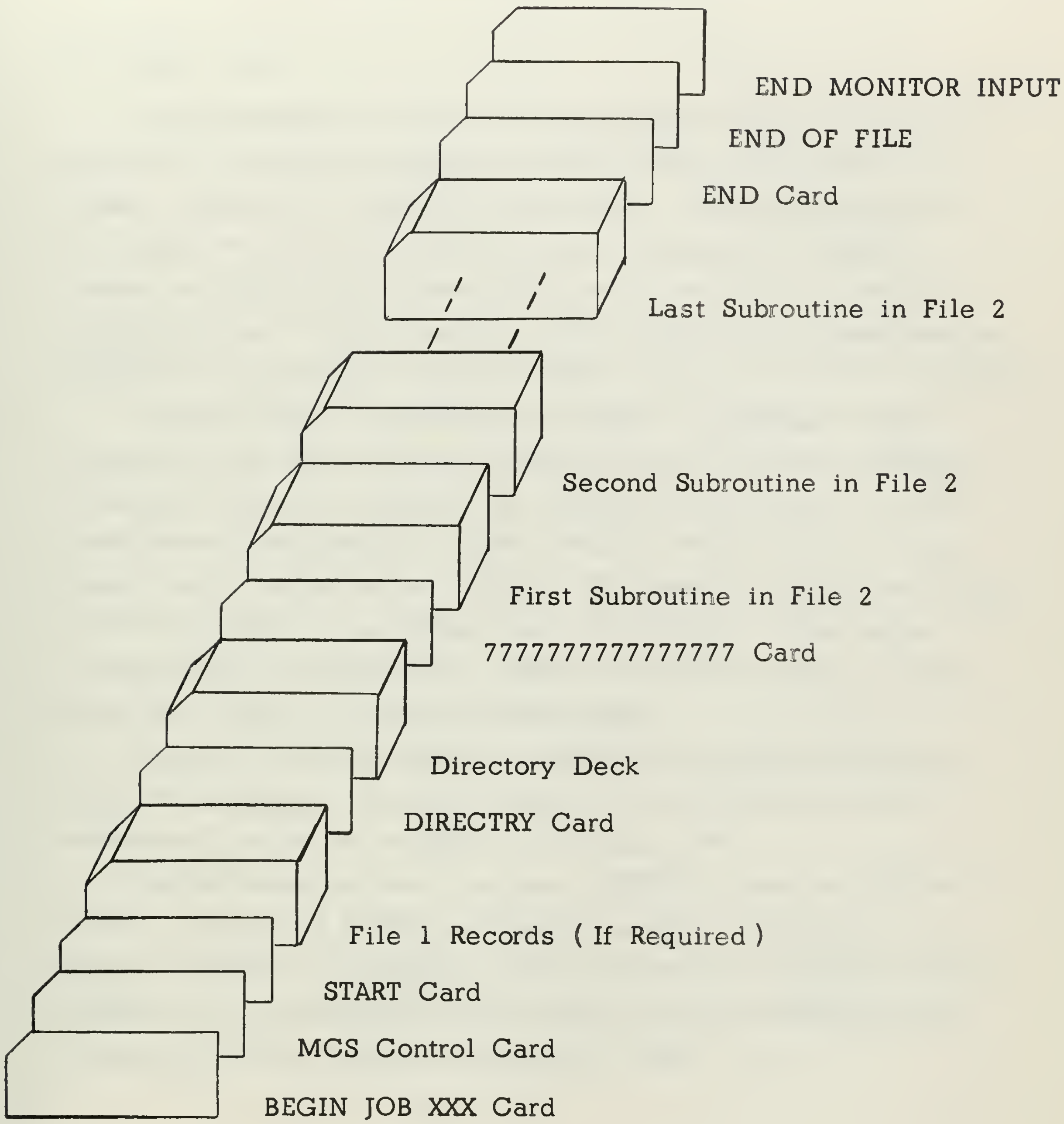

Figure A.2 Edit Input Deck

be a START card. This card contains the word "START" in columns 10-14 to produce a library tape of the same format as the old, see ref. 17 for other formats possible. The succeeding cards in the input deck are determined by the type of edit and the file of the library affected.

D. File 1 Edit

The information in file 1 is in <u>absolute</u> binary format, and the file is divided into three records. Each record must be added, replaced or deleted as an entity. The information to be added or replaced must have been prepared by CODAP1 using the ORG pseudo instruction and it must be a complete, <u>absolute</u> binary format program. The complete deck produced by CODAP1 is included (only the "begin job" card need be removed).

The edit input is composed of decks of <u>absolute</u> binary records, each preceded by a control card. This card contains a decimal integer in column 10, followed by a blank, R, or D. The integer specifies the record position within file 1 of the binary card images which follow. The blank specifies the record is to be added, R to replace, and D to delete. The decks composing the records must appear in the same order in which they will appear on the new library tape.

If any of the entry points in MCS are altered by this edit then the <u>complete</u> directory (with the new MCS entry point addresses) must be included in the edit input.

The Extended Recovery routine (EXTREC) uses the AET and flags contained in BOOT as absolute address locations. If these locations are changed, then they must be changed within EXTREC (by recompiling) and including the new EXTREC deck, between BOOT and MCS, in the file 1 edit.

E. File 2 Edit

The information in file 2 is in several records in relocatable binary format. The first record is the directory. A new version of the directory need not be included in the edit input deck when the changes to file 2 are replacements which do not affect record lengths or entry points. In all other cases the complete directory must be included.

The first record of each subroutine (normally there is only one record) must be composed of relocatable binary card images produced by CODAP1. For edits involving subroutines of more than one record see ref.17. Each record must be preceded by a control card containing the subroutine name, left-justified, in columns 1-8, a blank in column 9, and a decimal integer starting in column 10 followed by a blank, R, or D. This integer specifies the position of this record within the records of this subroutine (usually 1). The blank specifies that the record is to be added; R specifies it is to replace an existing one, D specifies it is to be deleted. If a D appears, a binary deck for that record must not appear in the edit deck.

The edit deck, see figure A.2, must be terminated by a card with the word END in columns 10-12. To finish the input job an "END OF FILE" and a "END MONITOR INPUT" are necessary.

F. Operation

The library edit program is called from the library as the Secondary Control System by a MCS control card. The edit input is read from the standard input unit; a new library tape is written on the logical unit #13; operating information is

written on the standard output unit and the comment to operator unit.

For an edit operation the MCS control record (card) might appear:

$_{9}^{7}$ELT,MGH,34000,O/13,5,1000.

During operation of the program, a listing is produced on the standard output unit. This listing contains each control card as it appears in the edit deck, all directory cards, and a message PREV REC X for each record transferred from the existing library to the new tape. The completion of the operation is indicated by the message EDIT COMPLETED. A sample edit listing is shown is figure A.1. Error diagnostics are written on the standard output unit and the comment to operator medium as errors are detected. These diagnostics are explained in table 1.

```
START MONITOR RUN.
BEGIN JOB 234
ELT,222,MGH,O/13,5,1000.
                          START
                          1R
PREV.                  2
                          3R
         DIRECTRY
         RESIDENT
         0000000000000000
         0430007700014557
         READ*
         WRITE*
         SELECT*
             .
             .
             .
         1205
         1212
         655
             .
             .
             .
         TYPEI/O
         0000000000000000
         0010000000300277
         TYPEI/O
         0
         CBF1*
         CBF2*
         SELECT*
         CARDREAD
         0000000000000001
         0010000000200466
             .
             .
             .
         WRITE*
         LOADER*
         7777777777777777
PREV.    TYPEI/O     1
         CARDREAD    1R
PREV.    PTI         1
PREV.    PTLOG       1
PREV.    BFT         1
             .
             .
             .
PREV.    MAP         1
PREV.    LIBEDIT     1
PREV.    COPY*       1
EDIT COMPLETED
```

Figure A.1
Sample Edit Listing

TABLE 1 LIBRARY EDIT ERROR DIAGNOSTICS

CKSUM ERROR XXXXXXXX LTN-50

An input column binary card checksum detected to be in error. XXXXXXXX will be the record number if the error is detected during a file 1 edit; or it will be the name of the subroutine if the error is detected during a file 2 edit.

DIRECTRY ERROR

An error has occurred in the directory.

DIROFLO ERROR XXXXXXXX

One of the eight directory tables requires more than 1/8 of available core. XXXXXXXX will be the name of the routine.

EDITINP ERROR XXXXXXXX

The order of the attempted edit is incorrect or incompatible with the directory. XXXXXXXX will be the name of the routine.

END OF TAPE

An end of tape mark is encountered during writing of the new library tape.

EPT ERROR

Two routines in the directory have the same entry point names.

OFLCORE ERROR XXXXXXXX

Available core is not large enough to allow forming a record. XXXXXXXX will be the record number if the error occurs during a file 1 edit; or it will be the name of the routine if the error occurs during a file 2 edit.

RANGE ERROR XXXXXXXX

An inconsistency exists between the IDC and RBD cards of a file 2 binary deck. XXXXXXXX will be the name of the routine.

READING ERROR XXXXXXXX LTN-YY

A. A persistent (not cleared after three tries) parity error or illegal BCD character is encountered when reading the library tape or the standard input unit.

B. An illegal or impossible number is detected on an edit control card. XXXXXXXX will be the record number if the error is detected during a file 1 edit; or it will be the name of the routine if the error is detected during a file 2 edit.

YY will be the number of the logical unit number on which the error was detected. 00 for the library or 50 for the standard input unit.

WRITING ERROR XXXXXXXX LTN-13

A persistent (not cleared after three tries) parity error is encountered when writing the new library tape. XXXXXXXX will be the number of the record if the error is detected during a file 1 edit; or it will be the name of the routine if the error is detected during a file 2 edit.

```
                                           IDENT      GRAFPLOT
RANGE                FWA   -  LWA+1
                    00000     02123
ENTRY POINTS
                    00022  GRAFPLOT
                    00000  AUTOGRAF
EXTERNAL SYMBOLS
                    00001    FLOATF
                    00002      XTOI
                    00003     XINTF
                    00004     ERROR
                    00005    BUFOUT
                    00006    INGOUT
                    00007      GOUT
                    00010   ENDGOUT
                    00011     WREOF
                    00012    IFUNIT
                    00013      BKSP
                    00014    WRITE*
                    00015    ERROR*

                   GRAFPLOT - AUTOGRAF
FORTRAN COMPATIBLE SUBROUTINE FOR PLOTTING DATA
      R.L. HOGG / D.C. GLOVER  1 APRIL 1963
           J.S. NAVAL POSTGRADUATE SCHOOL
                MONTEREY, CALIFORNIA

           INPUT PARAMETERS FOR GRAFPLOT ENTRY

1. MODCURV = 0  FIRST AND LAST CURVE FOR THIS GRA
             1  FIRST CURVE OF MANY
             2  INERMEDIATE CURVE
             3  FINAL CURVE FOR THIS GRAPH

2. NUMPTS  =    NUMBER OF POINTS-MUST BE LESS OR
3. X       =    LOCATION OF X ARRAY
4. Y       =    LOCATION OF Y ARRAY
5. LABEL   =    4 CHARACTER BCD LABEL FOR THIS CU
           =-0  WILL CAUSE AUTOMATIC SEQ. UP TO 8

6. INTERPS = 0  NO INTERPOLATION BETWEEN INPUT PO
           = 1 THRU 7-INTERPOLATE 1 TO 7 INTERMED

7. SFX     = 0  PROGRAM WILL FIND BEST SCALE FACT
           = A  SCALE FACTOR FOR X, UNITS/INCH

8. SFY     = 0  PROGRAM WILL FIND BEST SCALE FACT
           = B  SCALE FACTOR FOR Y, UNITS/INCH

9. IXOFFS  =    NO. OF INCHES TO OFFSET X AXIS
```

```
1
                                           10.IYOFFS  =    NO. OF INCHES TO OFFSET Y AXIS
                                           11.IWIDE   =    NO. OF INCHES FOR X AXIS, MAX=9
                                           12.IHIGH   =    NO. OF INCHES FOR Y AXIS, MAX=24
                                           13.MODE    = 0  AUTO CAL. BEST OFFSET OF AXES
                                                        1  LOCATE AXES CENTER
                                                        2  LOCATE AXES LOWER LEFT
                                                        3  LOCATE AXES UPPER LEFT
                                                        4  LOCATE AXES UPPER RIGHT
                                                        5  LOCATE AXES LOWER RIGHT

                                           14.TITLESIZ= 1-77        FIXED POINT MULT. FOR
                                                                    LETTER SIZE. BASIC SIZE
                                                                    IS .1 INCHES

                                           15.TITLE1  =    ADDRESS OF 1ST TITLE ARRAY
                                           16.TITLE2  =    ADDRESS OF 2ND TITLE ARRAY
                                                *          0 TO 2048 TITLES MAY BE USED
                                                *

                                                   INPUT PARAMETERS FOR AUTOGRAF ENTRY

                                           1. MODCURV
                                           2. NUMPTS
                                           3. X
                                           4. Y
                                           5. TITLE1       0 TO 2048 TITLES MAY BE USED
                                                *
                                                *

                     00022+              ENTRY    GRAFPLOT
                     00003+              ENTRY    AUTOGRAF
        00001                            EXT      FLOATF
        00002                            EXT      XTOI
        00003                            EXT      XINTF
        00004                            EXT      ERROR
        00005                            EXT      BUFOUT
        00006                            EXT      INGOUT
        00007                            EXT      GOUT
        00010                            EXT      ENDGOUT
        00011                            EXT      WREOF
        00012                            EXT      IFUNIT
        00013                            EXT      BKSP
        00014                            EXT      WRITE*
        00015                            EXT      ERROR*
```

```
1         00000+  00  0  77777   AUTOGRAF ZRO        **
                  20  0  01110+           STA        MODCURV
          00001+  21  0  01111+           STQ        NUMPTS
                  12  0  00000+           LDA        AUTOGRAF
          00002+  01  0  00030            ARS        24
                  60  0  00004+           SAU        *+2
          00003+  11  0  00001            INA        +1
                  61  0  00016+           SAL        ARGR2
          00004+  12  0  77777   +        LDA        **
                  20  0  00007+           STA        ARGU1
          00005+  12  0  01110+           LDA        MODCURV
                  16  0  01111+           LDQ        NUMPTS
          00006+  75  4  00022+  +        SLJ     4  GRAFPLOT
                  50  0  00000
          00007+  00  0  00000   ARGU1    OCT        0
                  00  0  00000
          00010+  00  0  00015+           ZRO        ALL7S
                  00  0  01014+           ZRO        =0
          00011+  00  0  01014+           ZRO        =0
                  00  0  01014+           ZRO        =0
          00012+  00  0  01014+           ZRO        =0
                  00  0  01014+           ZRO        =0
          00013+  00  0  01022+           ZRO        =9
                  00  0  01022+           ZRO        =9
          00014+  00  0  01014+           ZRO        =0
                  00  0  01017+           ZRO        =2
          00015+  77  7  77777   ALL7S    OCT        -0
                  77  7  77777
          00016+  00  0  00000   ARGR2    OCT        0
                  00  0  00000
          00017+  50  1  77777   PLOTEXIT ENI     1  **
                  50  2  77777            ENI     2  **
          00020+  50  3  77777            ENI     3  **
                  50  4  77777            ENI     4  **
          00021+  50  5  77777            ENI     5  **
                  50  6  77777            ENI     6  **

          00022+  75  0  77777   GRAFPLOT SLJ        **
                  50  0  00000            NOP
          00023+  56  1  00017+           SIU     1  PLOTEXIT
                  57  2  00017+           SIL     2  PLOTEXIT
          00024+  56  3  00020+           SIU     3  PLOTEXIT+1
                  57  4  00020+           SIL     4  PLOTEXIT+1
          00025+  56  5  00021+           SIU     5  PLOTEXIT+2
                  57  6  00021+           SIL     6  PLOTEXIT+2
          00026+  60  0  00027+           SAU        *+1
                  50  0  00000
```

```
00027+  12  0  77777   +              LDA          **
        20  0  01110+                 STA          MODCURV
00030+  07  0  00060                  LLS          48
        60  0  00031+                 SAU          *+1
00031+  12  0  77777   +              LDA          **
        50  0  00000
00032+  20  0  01111+  +              STA          NUMPTS
        11  0  77776                  INA          -1
00033+  60  0  00401+                 SAU          ST1006
        50  0  00000
00034+  15  0  01035+  +              SUB          =900
        22  3  00036+                 AJP     M    *+2
00035+  12  0  01035+  +              LDA          =900
        75  0  00032+                 SLJ          *-3
00036+  52  1  00022+  +              LIU     1    GRAFPLOT
        12  1  00000                  LDA     1    0
00037+  61  0  01113+                 SAL          Y1ADDR
        60  0  00355+                 SAU          JPTPROC
00040+  05  0  00030                  ALS          24
        61  0  01112+                 SAL          X1ADDR
00041+  60  0  00344+                 SAU          IPTPROC
        51  1  00001                  INI     1    1
00042+  12  1  00000                  LDA     1    0
        60  0  00043+                 SAU          *+1
00043+  12  0  77777   +              LDA          **
        20  0  01121+                 STA          INTERPS
00044+  12  1  00000                  LDA     1    0
        05  0  00030                  ALS          24
00045+  60  0  00046+                 SAU          *+1
        50  0  00000
00046+  12  0  77777   +              LDA          **
        20  0  01155+                 STA          LABEL
00047+  22  1  00056+                 AJP     N    LABJUMP
        22  2  00056+                 AJP     P    LABJUMP
00050+  12  0  01110+                 LDA          MODCURV
        50  0  00000
00051+  11  0  77775   +              INA          -2
        22  2  00053+                 AJP     P    *+2
00052+  12  0  01042+                 LDA          LABELCEL
        20  0  01043+                 STA          LABELCYC
00053+  10  0  00000                  ENA          0
        16  0  01043+                 LDQ          LABELCYC
00054+  07  0  00006                  LLS          6
        21  0  01043+                 STQ          LABELCYC
00055+  05  0  00044                  ALS          36
        20  0  01155+                 STA          LABEL
00056+  12  0  01110+ LABJUMP        LDA          MODCURV
        11  0  77775                  INA          -2
00057+  22  3  00063+                 AJP     M    SET2SCAL
```

```
         51 1 00001            INI  1 1
00060+   57 1 01120+           SIL  1 T1/2ADDR
         51 1 00004            INI  1 4
00061+   12 1 00000            LDA  1 0
         22 2 00124+           AJP  P HOWMANY
00062+   22 1 00124+           AJP  N HOWMANY
         75 0 00105+           SLJ    SET4AUTO
00063+   51 1 00001   SET2SCAL INI  1 1
         12 1 00000            LDA  1 0
00064+   61 0 01115+           SAL    SFYADDR
         05 0 00030            ALS    24
00065+   61 0 01114+           SAL    SFXADDR
         51 1 00001            INI  1 1
00066+   12 1 00000            LDA  1 0
         60 0 00071+           SAU    *+3
00067+   05 0 00030            ALS    24
         60 0 00070+           SAU    *+1
00070+   12 0 77777 +          LDA    **
         20 0 01075+           STA    IXOFFS
00071+   12 0 77777 +          LDA    **
         20 0 01076+           STA    IYOFFS
00072+   51 1 00001            INI  1 1
         12 1 00000            LDA  1 0
00073+   60 0 00076+           SAU    *+3
         05 0 00030            ALS    24
00074+   60 0 00075+           SAU    *+1
         50 0 00000
00075+   12 0 77777 +          LDA    **
         20 0 01077+           STA    IWIDE
00076+   12 0 77777 +          LDA    **
         20 0 01116+           STA    IHIGH
00077+   51 1 00001            INI  1 1
         12 1 00000            LDA  1 0
00100+   60 0 00102+           SAU    *+2
         05 0 00030            ALS    24
00101+   61 0 01067+           SAL    MODEADDR
         50 0 00000
00102+   12 0 77777 +          LDA    **
         20 0 01117+           STA    TITLESIZ
00103+   51 1 00001            INI  1 1
         57 1 01120+           SIL  1 T1/2ADDR
00104+   12 1 00000 +          LDA  1 0
         22 2 00110+           AJP  P *+4
00105+   22 1 00110+           AJP  N *+3
         50 0 00000
00106+   51 1 00001   SET4AUTO INI  1 1
         12 1 00000            LDA  1 0
00107+   41 0 01050+           SCL    CLEARMK
         20 0 01120+           STA    T1/2ADDR
```

1

```
00110+  12  0  01077+            LDA        IWIDE
        15  0  01022+            SUB        =9
00111+  22  0  00113+  +         AJP   Z    *+2
        22  3  00113+            AJP   M    *+2
00112+  12  0  01022+            LDA        =9
        20  0  01077+            STA        IWIDE
00113+  12  0  01116+            LDA        IHIGH
        15  0  01025+            SUB        =20
00114+  22  0  00116+  +         AJP   Z    *+2
        22  3  00116+            AJP   M    *+2
00115+  12  0  01025+            LDA        =20
        20  0  01116+            STA        IHIGH
00116+  10  0  01077+            ENA        IWIDE
        75  4  X00001            RTJ        FLOATF
00117+  75  4  X00004  +         RTJ        ERROR
        50  0  00000
00120+  20  0  01064+  +         STA        WIDTH
        10  0  01116+            ENA        IHIGH
00121+  75  4  X00001            RTJ        FLOATF
        50  0  00000
00122+  75  4  X00004  +         RTJ        ERROR
        50  0  00000
00123+  20  0  01065+  +         STA        HEIGHT
        50  1  00000             ENI   1    0
00124+  12  0  01120+  HOWMANY   LDA        T1/2ADDR
        20  0  01170+            STA        ITEMP
00125+  60  0  00126+            SAU        *+1
        50  0  00000
00126+  12  0  77777   +         LDA        **
        20  0  01171+            STA        ITEMP+1
00127+  16  0  01047+            LDQ        LOWMASK
        44  0  01171+            LDL        ITEMP+1
00130+  22  1  00132+  +         AJP   N    *+2
        51  1  00002             INI   1    2
00131+  72  0  01170+            RAO        ITEMP
        75  0  00125+            SLJ        HOWMANY+1
00132+  06  0  00030             QLS        24
        44  0  01171+            LDL        ITEMP+1
00133+  22  1  00135+  +         AJP   N    *+2
        72  0  01170+            RAO        ITEMP
00134+  51  1  00001             INI   1    1
        50  0  00000
00135+  57  1  01154+  +         SIL   1    KTITLE
        12  0  01170+            LDA        ITEMP
00136+  11  0  00001             INA        1
        60  0  00022+            SAU        GRAFPLOT

                                            TEST IF FIRST CURVE ENTRY, THIS GRAPH
```

```
00137+  12  0  01110+ +          LDA       MODCURV
        11  0  77775             INA       -2
00140+  22  2  00340+            AJP    P  PLOTCURV              NOT 1ST, GO PLOT CURVE
        50  0  00000
00141+  75  4  00435+ +          RTJ       SCALE                 GO TEST/PERFORM SCALING
        50  0  00000
00142+  12  0  01102+ CALCVALS  LDA       XSCALE
        20  0  01072+            STA       X/YSCALE
00143+  75  4  00717+            RTJ       ENCODE
        50  0  00000
00144+  12  0  01170+ +          LDA       ITEMP
        20  0  01104+            STA       XSCLAB1
00145+  12  0  01171+            LDA       ITEMP+1
        20  0  01105+            STA       XSCLAB2
00146+  16  0  01044+            LDQ       MK1
        44  0  01170+            LDL       ITEMP
00147+  05  0  00014             ALS       12
        20  0  01100+            STA       LABELX
00150+  12  0  01103+            LDA       YSCALE
        20  0  01072+            STA       X/YSCALE
00151+  75  4  00717+            RTJ       ENCODE
        50  0  00000
00152+  12  0  01170+ +          LDA       ITEMP
        20  0  01106+            STA       YSCLAB1
00153+  12  0  01171+            LDA       ITEMP+1
        20  0  01107+            STA       YSCLAB2
00154+  16  0  01044+            LDQ       MK1
        44  0  01170+            LDL       ITEMP
00155+  05  0  00014             ALS       12
        20  0  01101+            STA       LABELY
00156+  10  0  00000             ENA       0
        20  0  01136+            STA       IH
00157+  20  0  01137+            STA       JV
        12  0  01075+            LDA       IXOFFS
00160+  24  0  01033+            MUI       =100
        20  0  01140+            STA       JH
00161+  15  0  01025+            SUB       =25
        20  0  01141+            STA       JHL
00162+  12  0  01077+            LDA       IWIDE
        24  0  01033+            MUI       =100
00163+  20  0  01142+            STA       LH
        14  0  01136+            ADD       IH
00164+  15  0  01021+            SUB       =8
        20  0  01143+            STA       IHL
00165+  13  0  01033+            LAC       =100
        20  0  01144+            STA       INCRIHL
00166+  20  0  01122+            STA       INCRJVL
        12  0  01077+            LDA       IWIDE
00167+  15  0  01075+            SUB       IYOFFS
```

```
        24  0  01100+        MUI      LABELX
00170+  20  0  01123+        STA      IVH
        13  0  01100+        LAC      LABELX
00171+  20  0  01124+        STA      INCRVH
        12  0  01077+        LDA      IWIDE
00172+  11  0  00001         INA      1
        20  0  01125+        STA      NH
00173+  10  0  00204         ENA      204B
        20  0  01150+        STA      LSHOH
00174+  12  0  01076+        LDA      IYOFFS
        24  0  01033+        MUI      =100
00175+  20  0  01145+        STA      IV
        12  0  01116+        LDA      IHIGH
00176+  24  0  01033+        MUI      =100
        20  0  01146+        STA      LV
00177+  12  0  01076+        LDA      IYOFFS
        24  0  01033+        MUI      =100
00200+  15  0  01031+        SUB      =70
        20  0  01126+        STA      IVL
00201+  12  0  01146+        LDA      LV
        11  0  00012         INA      10
00202+  20  0  01127+        STA      JVL
        12  0  01116+        LDA      IHIGH
00203+  15  0  01075+        SUB      IXOFFS
        24  0  01101+        MUI      LABELY
00204+  20  0  01130+        STA      IVV
        13  0  01101+        LAC      LABELY
00205+  20  0  01131+        STA      INCRVV
        12  0  01116+        LDA      IHIGH
00206+  11  0  00001         INA      1
        20  0  01132+        STA      NV
00207+  10  0  00204         ENA      204B
        20  0  01133+        STA      LSVOV
00210+  12  0  01136+        LDA      IH
        20  0  01134+        STA      IT
00211+  13  0  01053+        LAC      LOWMARG
        24  0  01033+        MUI      =100
00212+  20  0  01135+        STA      JT
        10  0  00004         ENA      4
00213+  20  0  01147+        STA      ITOR
        12  0  01154+        LDA      KTITLE
00214+  11  0  00002         INA      2
        20  0  01154+        STA      KTITLE

                                      WRITE TITLE CONTROL RECORD

00215+  16  0  01045+        LDQ      MK2
        44  0  01134+        LDL      IT
00216+  05  0  00014         ALS      12
```

```
          43  0   01135+              SSU         JT
00217+    05  0   00014               ALS         12
          43  0   01147+              SSU         ITOR
00220+    05  0   00014               ALS         12
          43  0   01154+              SSU         KTITLE
00221+    20  0   01170+              STA         ITEMP
          50  0   00000
00222+    10  0   01015+ +            ENA         =1
          04  0   01027+              ENQ         =48
00223+    75  4  X00005               RTJ         BUFOUT
          50  0   00000
00224+    00  0   01170+ +            ZRO         ITEMP
          00  0   01170+              ZRO         ITEMP
00225+    75  4  X00004  +            RTJ         ERROR
          50  0   00000
00226+    75  4   00737+ +            RTJ         TPCHK
          50  0   00000

                                                  WRITE OUT AXIS SCALE TITLES

00227+    12  0   01056+ +            LDA         SCALEX1
          16  0   01044+              LDQ         MK1
00230+    06  0   00006               QLS         6
          43  0   01054+              SSU         SCALSIZ
00231+    20  0   01170+              STA         ITEMP
          12  0   01057+              LDA         SCALEX2
00232+    20  0   01171+              STA         ITEMP+1
          12  0   01104+              LDA         XSCLAB1
00233+    20  0   01172+              STA         ITEMP+2
          12  0   01105+              LDA         XSCLAB2
00234+    20  0   01173+              STA         ITEMP+3
          50  0   00000
00235+    10  0   01015+ +            ENA         =1
          04  0   01027+              ENQ         =48
00236+    75  4  X00005               RTJ         BUFOUT
          50  0   00000
00237+    00  0   01170+ +            ZRO         ITEMP
          00  0   01173+              ZRO         ITEMP+3
00240+    75  4  X00004  +            RTJ         ERROR
          50  0   00000
00241+    75  4   00737+ +            RTJ         TPCHK
          50  0   00000
00242+    12  0   01060+ +            LDA         SCALEY1
          16  0   01044+              LDQ         MK1
00243+    06  0   00006               QLS         6
          43  0   01054+              SSU         SCALSIZ
00244+    20  0   01202+              STA         ITEMP+10
          12  0   01061+              LDA         SCALEY2
00245+    20  0   01203+              STA         ITEMP+11
```

```
                12  0   01105+                LDA          YSCLAB1
    00246+      20  0   01204+                STA          ITEMP+12
                12  0   01107+                LDA          YSCLAB2
    00247+      20  0   01205+                STA          ITEMP+13
                50  0   00000
    00250+      10  0   01015+  +             ENA          =1
                04  0   01027+                ENQ          =48
    00251+      75  4  X00005                 RTJ          BUFOUT
                50  0   00000
    00252+      00  0   01202+  +             ZRO          ITEMP+10
                00  0   01205+                ZRO          ITEMP+13
1   00253+      75  4  X00004   +             RTJ          ERROR
                50  0   00000
    00254+      75  4   00737+  +             RTJ          TPCHK
                50  0   00000

                                                           LOOP TO WRITE OUT TITLES

    00255+      53  1   01154+                LIL      1   KTITLE
                51  1   77775                 INI      1   -2
    00256+      12  0   01051+                LDA          CONTROL2
                20  0   01052+                STA          CONTR1
    00257+      12  0   01120+  SETITLE1      LDA          T1/2ADDR
                60  0   00260+                SAU          *+1
    00260+      12  0   77777   +             LDA          **
                05  0   00030                 ALS          24
    00261+      60  0   00265+  SETITLE2      SAU          STRTITLE
                50  0   00000
    00262+      55  1   00263+  +             IJP      1   *+1
                75  0   00306+                SLJ          CONTROL
    00263+      50  4   00024                 ENI      4   20
                10  0   00000                 ENA          0
    00264+      20  4   01207+  KLEER         STA      4   STORE
                55  4   00264+                IJP      4   KLEER
    00265+      50  2   00000   +             ENI      2   0
                12  0   01117+                LDA          TITLESIZ
    00266+      16  2   77777   STRTITLE      LDQ      2   **
                07  0   00052                 LLS          42
    00267+      20  2   01207+                STA      2   STORE
                07  0   00006                 LLS          6
    00270+      20  0   01225+                STA          STORE+14
                50  0   00000
    00271+      12  0   01117+  +             LDA          TITLESIZ
                24  0   01021+                MUI          =8
    00272+      70  0   01226+                RAD          STORE+15
                15  0   01033+                SUB          =100
    00273+      22  2   00275+                AJP      P   NOMORR
                12  0   01225+                LDA          STORE+14
    00274+      54  2   00011   +             ISK      2   9
```

```
         75  0  00266+            SLJ       STRTITLE
00275+   10  0  01015+ NOMORR     ENA       =1
         04  0  01027+            ENQ       =48
00276+   75  4 X00005             RTJ       BUFOUT
         50  0  00000
00277+   00  0  01207+ +          ZRO       STORE
         00  0  01221+            ZRO       STORE+10
00300+   75  4 X00004  +          RTJ       ERROR
         50  0  00000
00301+   75  4  00737+ +          RTJ       TPCHK
         50  0  00000
00302+   37  0  01052+ +          SSH       CONTR1
         75  0  00305+            SLJ       *+3
00303+   12  0  01120+ +          LDA       T1/2ADDR
         60  0  00304+            SAU       *+1
00304+   12  0  77777  +          LDA       **
         75  0  00261+            SLJ       SETITLE2
00305+   72  0  01120+ +          RAO       T1/2ADDR
         75  0  00257+            SLJ       SETITLE1

                                            WRITE AXIS  CONTROL RECORD

00306+   16  0  01045+ CONTROL    LDQ       MK2
         44  0  01136+            LDL       IH
00307+   05  0  00014             ALS       12
         43  0  01140+            SSU       JH
00310+   05  0  00014             ALS       12
         43  0  01142+            SSU       LH
00311+   05  0  00014             ALS       12
         43  0  01143+            SSU       IHL
00312+   20  0  01170+            STA       ITEMP
         44  0  01141+            LDL       JHL
00313+   05  0  00014             ALS       12
         43  0  01144+            SSU       INCRIHL
00314+   05  0  00014             ALS       12
         43  0  01123+            SSU       IVH
00315+   05  0  00014             ALS       12
         43  0  01124+            SSU       INCRVH
00316+   20  0  01171+            STA       ITEMP+1
         44  0  01125+            LDL       NH
00317+   05  0  00014             ALS       12
         43  0  01150+            SSU       LSHOH
00320+   05  0  00014             ALS       12
         43  0  01145+            SSU       IV
00321+   05  0  00014             ALS       12
         43  0  01137+            SSU       JV
00322+   20  0  01172+            STA       ITEMP+2
         44  0  01146+            LDL       LV
00323+   05  0  00014             ALS       12
```

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```
           43  0  01126+            SSU         IVL
00324+     05  0  00014             ALS         12
           43  0  01127+            SSU         JVL
00325+     05  0  00014             ALS         12
           43  0  01122+            SSU         INCRJVL
00326+     20  0  01173+            STA         ITEMP+3
           44  0  01130+            LDL         IVV
00327+     05  0  00014             ALS         12
           43  0  01131+            SSU         INCRVV
00330+     05  0  00014             ALS         12
           43  0  01132+            SSU         NV
00331+     05  0  00014             ALS         12
           43  0  01133+            SSU         LSVOV
00332+     20  0  01174+            STA         ITEMP+4
           50  0  00000
00333+     10  0  01015+ +          ENA         =1
           04  0  01027+            ENQ         =48
00334+     75  4 X00005             RTJ         BUFOUT
           50  0  00000
00335+     00  0  01170+ +          ZRO         ITEMP
           00  0  01174+            ZRO         ITEMP+4
00336+     75  4 X00004  +          RTJ         ERROR
           50  0  00000
00337+     75  4  00737+ +          RTJ         TPCHK
           50  0  00000
1
                                                WRITE CURVE DATA RECORD

00340+     10  0  01210+ PLOTCURV   ENA         STORE+1
           41  0  01050+            SCL         CLEARMK
00341+     61  0  01153+            SAL         BUFAD
           12  0  01051+            LDA         CONTROL2
00342+     20  0  01052+            STA         CONTR1
           12  0  01121+            LDA         INTERPS
00343+     20  0  01207+            STA         STORE
           50  3  00000             ENI     3   0
00344+     12  3  77777  IPTPROC    LDA     3   **
           32  0  01034+            FMU         =100.0
00345+     33  0  01102+            FDV         XSCALE
           20  0  01170+            STA         ITEMP
00346+     10  0  01170+            ENA         ITEMP
           75  4 X00003             RTJ         XINTF
00347+     75  4 X00004  +          RTJ         ERROR
           50  0  00000
00350+     14  0  01145+ +          ADD         IV
           50  0  00000
00351+     22  2  00352+ +          AJP     P   *+1
           10  0  00000             ENA         0
00352+     20  0  01151+            STA         IPT
```

```
         15  0  01142+            SUB        LH
00353+   22  3  00355+            AJP     M  JPTPROC
         12  0  01142+            LDA        LH
00354+   20  0  01151+            STA        IPT
         50  0  00000
00355+   12  3  77777   JPTPROC   LDA     3  **
         32  0  01034+            FMU        =100.0
00356+   33  0  01103+            FDV        YSCALE
         20  0  01170+            STA        ITEMP
00357+   10  0  01170+            ENA        ITEMP
         75  4 X00003             RTJ        XINTF
00360+   75  4 X00004   +         RTJ        ERROR
         50  0  00000
00361+   14  0  01140+  +         ADD        JH
         50  0  00000
00362+   22  2  00363+  +         AJP     P  *+1
         10  0  00000             ENA        0
00363+   20  0  01152+            STA        JPT
         15  0  01146+            SUB        LV
00364+   22  3  00365+            AJP     M  STORENTR
         12  0  01145+            LDA        LV
00365+   20  0  01152+            STA        JPT
         50  0  00000
00366+   04  0  07777   STORENTR  ENQ        7777B
         44  0  01151+            LDL        IPT
00367+   37  0  01052+            SSH        CONTR1
         75  0  00374+            SLJ        ST1005
00370+   05  0  00044             ALS        36
         20  7  01153+            STA     7  BUFAD
00371+   44  0  01152+            LDL        JPT
         05  0  00030             ALS        24
00372+   06  0  00044             QLS        36
         43  7  01153+            SSU     7  BUFAD
00373+   20  7  01153+            STA     7  BUFAD
         75  0  00401+            SLJ        ST1006
00374+   05  0  00014   ST1005    ALS        12
         16  0  01045+            LDQ        MASK
00375+   43  7  01153+            SSU     7  BUFAD
         04  0  07777             ENQ        7777B
00376+   43  0  01152+            SSU        JPT
         20  7  01153+            STA     7  BUFAD
00377+   72  0  01153+            RAO        BUFAD
         10  0  00000             ENA        0
00400+   20  7  01153+            STA     7  BUFAD
         50  0  00000
00401+   54  3  77777   ST1006    ISK     3  **
         75  0  00344+            SLJ        IPTPROC
00402+   12  7  01153+            LDA     7  BUFAD
         04  0  00000             ENQ        0
```

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```
    00403+  07  0   00030             LLS        24
            23  0   00414 +           QJP        ST1007
    00404+  07  0   00060             LLS        48
            16  0   01036 +           LDQ        NFLAG
    00405+  07  0   00030             LLS        24
            20  7   01153 +           STA     7  BUFAD
    00406+  72  0   01153 +           RAD        BUFAD
            50  0   00000             NOP
    00407+  10  0   00000   +         ENA        0
            16  0   01155 +           LDQ        LABEL
    00410+  07  0   00030             LLS        24
            04  0   00104             ENQ        104B
    00411+  06  0   00044             QLS        36
            07  0   00030             LLS        24
    00412+  20  7   01153 +           STA     7  BUFAD
            12  0   01153 +           LDA        BUFAD
    00413+  61  0   00423 +           SAL        INITERM
            75  0   00421 +           SLJ        ST1008
    00414+  12  0   01037 + ST1007    LDA        INFLAG
            16  0   01155 +           LDQ        LABEL
    00415+  07  0   00030             LLS        24
            20  7   01153 +           STA     7  BUFAD
    00416+  72  0   01153 +           RAD        BUFAD
            10  0   00104             ENA        104B
    00417+  05  0   00044             ALS        36
            20  7   01153 +           STA     7  BUFAD
    00420+  12  0   01153 +           LDA        BUFAD
            61  0   00423 +           SAL        INITERM
    00421+  10  0   01015 + ST1008    ENA        =1
            04  0   01027 +           ENQ        =48
    00422+  75  4  X00005             RTJ        BUFOUT
            50  0   00000
    00423+  00  0   01207 + INITERM   ZRO        STORE
            00  0   77777             ZRO        **
    00424+  75  4  X00004   +         RTJ        ERROR
            50  0   00000
    00425+  75  4   00737 + +         RTJ        TPCHK
            50  0   00000
    00426+  12  0   01110 + +         LDA        MODCURV
            22  3   00431 +           AJP     M  *+3
1   00427+  22  0   00431 +           AJP     Z  *+2
            50  0   00000
    00430+  11  0   77774   +         INA        -3
            22  3   00434 +           AJP     M  *+4
    00431+  10  0   01027 + +         ENA        =48
            75  4  X00011             RTJ        WREOF
    00432+  75  4  X00004   +         RTJ        ERROR
            50  0   00000
    00433+  12  0   01042 + +         LDA        LABELCEL
```

```
          76 1 00434+              SLS    1  *+1
00434+    75 0 00017+ +            SLJ       PLOTEXIT
          50 0 00000
00435+    75 0 77777  SCALE        SLJ       **
          12 0 01114+              LDA       SFXADDR
00436+    60 0 00437+              SAU       *+1
          50 0 00000
00437+    12 0 77777  +            LDA       **
          20 0 01102+              STA       XSCALE
00440+    22 1 00443+ +            AJP    N  *+3
          75 4 00451+              RTJ       SCALEX
00441+    10 0 01102+ +            ENA       XSCALE
          04 0 01075+              ENQ       IYOFFS
00442+    75 4 00732+ +            RTJ       ALLZEROS
          50 0 00000
00443+    12 0 01115+ +            LDA       SFYADDR
          60 0 00444+              SAU       *+1
00444+    12 0 77777  +            LDA       **
          20 0 01103+              STA       YSCALE
00445+    22 1 00450+ +            AJP    N  *+3
          75 4 00475+              RTJ       SCALEY
00446+    10 0 01103+ +            ENA       YSCALE
          04 0 01075+              ENQ       IXOFFS
00447+    75 4 00732+ +            RTJ       ALLZEROS
          50 0 00000
00450+    75 0 00435+ +            SLJ       SCALE
          50 0 00000
00451+    75 0 77777  SCALEX       SLJ       **
          12 0 01112+              LDA       X1ADDR
00452+    16 0 01111+              LDQ       NUMPTS
          75 4 00577+              RTJ       MAX/MIN
00453+    20 0 01155+ +            STA       XMAX
          21 0 01161+              STQ       XMIN
00454+    22 2 00455+ +            AJP    P  *+1                  SET ABSOLUTE
          10 0 00000               ENA       0                           XMAX OR
00455+    20 0 01157+              STA       AXMAX                          (=0 IF XMAX IS -)
          20 0 01160+              STA       AMAX
00456+    12 0 01161+              LDA       XMIN                 SET
          50 0 00000
00457+    22 3 00460+ +            AJP    M  *+1                     ABSOLUTE
          10 0 77777               ENA       -0                          XMIN OR
00460+    42 0 00015+              SCM       ALL7S                          (=0 IF XMIN IS +)
          20 0 01162+              STA       AXMIN
00461+    20 0 01163+              STA       AMIN
          12 0 01064+              LDA       WIDTH                GO SET
00462+    20 0 01063+              STA       LENGTH                  AXMAX/AXMIN/XTOTAL
          10 0 77777               ENA       -0                          IN ACCORDANCE
00463+    20 0 01040+              STA       X/YFLAG                        WITH MODE SELECTED
          75 4 00652+              RTJ       GETTOTAL
```

```
00464+  12  0  01062+ +            LDA        TOTAL
         22  1  00466+               AJP    N   *+2
00465+  75  0  00451+               SLJ        SCALEX
         50  0  00000
00466+  52  1  00451+ +            LIU    1   SCALEX               BUILD
         51  1  00002                INI    1   2                       NORMAL
00467+  56  1  00451+               SIU    1   SCALEX                      RETURN
         75  4  00521+               RTJ        SCALEX/Y             GO SCALE X
00470+  12  0  01072+ +            LDA        X/YSCALE
         20  0  01102+               STA        XSCALE
00471+  12  0  01063+               LDA        LENGTH
         20  0  01064+               STA        WIDTH
00472+  75  4  00622+               RTJ        CALCOFFS
         50  0  00000
00473+  12  0  01074+ +            LDA        IOFFS
         20  0  01076+               STA        IYOFFS
00474+  75  0  00451+               SLJ        SCALEX
         50  0  00000
00475+  75  0  77777   SCALEY      SLJ        **
         12  0  01113+               LDA        Y1ADDR
00476+  16  0  01111+               LDQ        NUMPTS
         75  4  00577+               RTJ        MAX/MIN
00477+  20  0  01164+ +            STA        YMAX
         21  0  01165+               STQ        YMIN
00500+  22  2  00501+ +            AJP    P   *+1                  SET ABSOLUTE
         10  0  00000                ENA        0                          YMAX OR
00501+  20  0  01165+               STA        AYMAX                         (=0 IF YMAX IS -)
         20  0  01160+               STA        AMAX
00502+  12  0  01165+               LDA        YMIN                 SET
         50  0  00000
00503+  22  3  00504+ +            AJP    M   *+1                     ABSOLUTE
         10  0  77777                ENA        -0                         YMIN OR
00504+  42  0  00015+               SCM        ALL7S                         (=0 IF YMIN IS +)
         20  0  01167+               STA        AYMIN
00505+  20  0  01163+               STA        AMIN
         12  0  01065+               LDA        HEIGHT
00506+  20  0  01063+               STA        LENGTH
         10  0  00000                ENA        +0
00507+  20  0  01040+               STA        X/YFLAG              SET FOR Y SCALING
         75  4  00652+               RTJ        GETTOTAL
00510+  12  0  01062+ +            LDA        TOTAL
         22  1  00512+               AJP    N   *+2
00511+  75  0  00475+               SLJ        SCALEY
         50  0  00000
00512+  52  1  00475+ +            LIU    1   SCALEY               BUILD
         51  1  00002                INI    1   2                       NORMAL
00513+  56  1  00475+               SIU    1   SCALEY                      RETURN
         75  4  00521+               RTJ        SCALEX/Y             GO SCALE Y
00514+  12  0  01072+ +            LDA        X/YSCALE
```

```
         20 0  01103+            STA      YSCALE
00515+   12 0  01063+            LDA      LENGTH
         20 0  01065+            STA      HEIGHT
00516+   75 4  00622+            RTJ      CALCOFFS
         50 0  00000
00517+   12 0  01074+  +         LDA      IOFFS
         20 0  01075+            STA      IXOFFS
00520+   75 0  00475+            SLJ      SCALEY
         50 0  00000
00521+   75 0  77777   SCALEX/Y  SLJ      **                  EXIT
         10 0  00001             ENA      1
00522+   20 0  01041+            STA      O/UFLAG
         20 0  01066+            STA      EXPONENT
00523+   50 2  00000             ENI    2 0
         12 0  00574+            LDA      QUANTAB
00524+   20 0  01070+            STA      QUANTA
         50 0  00000
00525+   10 0  01024+  TESTSCAL  ENA      =10.0
         04 0  01065+            ENQ      EXPONENT
00526+   75 4 X00002             RTJ      XTOI
         50 0  00000
00527+   75 4 X00004   +         RTJ      ERROR
         50 0  00000
00530+   32 0  01070+  +         FMU      QUANTA
         20 0  01071+            STA      TEMPSCAL
00531+   32 0  01063+            FMU      LENGTH
         31 0  01062+            FSB      TOTAL
00532+   22 0  00534+            AJP    Z HITSCALE
         22 3  00535+            AJP    M UNDRTEST
00533+   75 0  00542+            SLJ      OVERTEST
         50 0  00000
00534+   12 0  01071+  HITSCALE  LDA      TEMPSCAL
         20 0  01072+            STA      X/YSCALE
00535+   75 0  00521+            SLJ      SCALEX/Y
         50 0  00000
00536+   12 0  01041+  UNDRTEST  LDA      O/UFLAG             RESCALE IF FIRST PASS
         22 1  00550+            AJP    N URESCALE
00537+   36 0  01041+  +         SSK      O/UFLAG             O/UFLAG=+ IF OVER BEFORE
         75 0  00554+            SLJ      UP1/OUT                     - IF UNDER BEFORE
00540+   75 4  00562+            RTJ      INCQUANT            INCREASE SCALE
         50 0  00000
00541+   75 0  00525+  +         SLJ      TESTSCAL
         50 0  00000
00542+   12 0  01041+  OVERTEST  LDA      O/UFLAG
         22 1  00552+            AJP    N ORESCALE
00543+   36 0  01041+            SSK      O/UFLAG
         75 0  00545+            SLJ      LOWERSCL
00544+   12 0  01071+            LDA      TEMPSCAL
         20 0  01072+            STA      X/YSCALE
```

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```
00545+  75  0  00521+             SLJ        SCALEX/Y
         50  0  00000
00546+  75  4  00566+  LOWERSCL    RTJ        DECQUANT
         50  0  00000
00547+  75  0  00525+  +           SLJ        TESTSCAL
         50  0  00000
00550+  10  0  77777   URESCALE    ENA        -0
         20  0  01041+             STA        0/UFLAG
00551+  75  0  00525+              SLJ        TESTSCAL
         50  0  00000
00552+  10  0  00000   ORESCALE    ENA        0
         20  0  01041+             STA        0/UFLAG
00553+  75  0  00525+              SLJ        TESTSCAL
         50  0  00000
00554+  75  4  00562+  UP1/OUT     RTJ        INCQUANT
         50  0  00000
00555+  10  0  01024+  +           ENA        =10.0
         04  0  01065+             ENQ        EXPONENT
00556+  75  4 X00002               RTJ        XTOI
         50  0  00000
00557+  75  4 X00004   +           RTJ        ERROR
         50  0  00000
00560+  32  0  01070+  +           FMU        QUANTA
         20  0  01072+             STA        X/YSCALE
00561+  75  0  00521+              SLJ        SCALEX/Y
         50  0  00000
00562+  75  0  77777   INCQUANT    SLJ        **
         52  3  00562+             LIU     3  *
00563+  56  3  00573+              SIU     3  GOTEST+1
         50  0  00000
00564+  54  2  00002   +           ISK     2  2
         75  0  00572+             SLJ        GOTEST
00565+  72  0  01066+              RAO        EXPONENT
         75  0  00572+             SLJ        GOTEST
00566+  75  0  77777   DECQUANT    SLJ        **
         52  3  00566+             LIU     3  *
00567+  56  3  00573+              SIU     3  GOTEST+1
         50  0  00000
00570+  55  2  00572+  +           IJP     2  GOTEST
         50  0  00000
00571+  73  0  01066+  +           RSO        EXPONENT
         50  2  00002              ENI     2  2
00572+  12  2  00574+  GOTEST      LDA     2  QUANTAB
         20  0  01070+             STA        QUANTA
00573+  75  0  77777               SLJ        **
         50  0  00000
00574+  20  0  14000   QUANTAB     DEC        1.0
         00  0  00000
00575+  20  0  24000               DEC        2.0
```

```
         00 0 00000
00576+   20 0 35000                DEC         5.0
         00 0 00000
00577+   75 0 77777   MAX/MIN     SLJ         **
         56 1 00617+              SIU     1   RESTOR
00600+   60 0 00605+              SAU         SET1
         61 0 00607+              SAL         OPERATE
00601+   61 0 00610+              SAL         SET2
         61 0 00612+              SAL         NOTBIGR
00602+   61 0 00613+              SAL         SET3
         07 0 00060               LLS         48              Q TO A
00603+   11 0 77776               INA         -1
         60 0 00615+              SAU         TESTING         SET NUMBER IN ARRAY
00604+   50 1 00000               ENI     1   0
         50 0 00000
00605+   12 1 77777   SET1        LDA     1   **
         20 0 00620+              STA         MAXARG          PRIME ROUTINE
00606+   20 0 00621+              STA         MINARG
         50 0 00000
1 00607+ 12 0 00620+  OPERATE     LDA         MAXARG          LOOP
         31 1 77777               FSB     1   **
00610+   22 2 00612+  SET2        AJP     2   NOTBIGR         JUMP IF POSITIVE
         12 1 77777               LDA     1   **
00611+   20 0 00620+              STA         MAXARG          NEW MAXARG
         75 0 00615+              SLJ         TESTING
00612+   12 0 00621+  NOTBIGR     LDA         MINARG
         31 1 77777               FSB     1   **
00613+   22 3 00615+  SET3        AJP     3   TESTING         JUMP IF NEGATIVE
         12 1 77777               LDA     1   **
00614+   20 0 00621+              STA         MINARG          NEW MINARG
         50 0 00000               ENI         0
00615+   54 1 77777   TESTING     ISK     1   **              TEST FOR ALL ARGUMENTS
         75 0 00607+              SLJ         OPERATE
00616+   12 0 00620+              LDA         MAXARG
         16 0 00621+              LDQ         MINARG
00617+   50 1 77777   RESTOR      ENI     1   **
         75 0 00577+              SLJ         MAX/MIN         EXIT
00620+                MAXARG      BSS         1
00621+                MINARG      BSS         1

00622+   75 0 77777   CALCOFFS    SLJ         **
         12 7 01067+              LDA     7   MODEADDR
00623+   22 2 00624+              AJP     P   MODE0
         10 0 00000               ENA         0
00624+   22 1 00632+  MODE0       AJP     N   MODE1
         12 0 01163+              LDA         AMIN
00625+   33 0 01072+              FDV         X/YSCALE
         30 0 01015+              FAD         =1.0
00626+   20 0 01073+  CONVERT     STA         TEMP
```

```
         10  0  01073+             ENA         TEMP
00627+   75  4 X00003              RTJ         XINTF
         50  0  00000
00630+   75  4 X00004   +          RTJ         ERROR
         50  0  00000
00631+   20  0  01074+  +          STA         IOFFS
         75  0  00622+             SLJ         CALCOFFS
00632+   11  0  77776   MODE1      INA         -1
         22  1  00635+             AJP     N   MODE2
00633+   12  0  01063+             LDA         LENGTH
         33  0  01020+             FDV         =2.0
00634+   75  0  00626+             SLJ         CONVERT
         50  0  00000
00635+   11  0  77776   MODE2      INA         -1
         22  1  00637+             AJP     N   MODE3
00636+   10  0  00000              ENA         0
         75  0  00626+             SLJ         CONVERT
00637+   11  0  77776   MODE3      INA         -1
         22  1  00643+             AJP     N   MODE4
00640+   36  0  01040+             SSK         X/YFLAG
         75  0  00642+             SLJ         SETMOD3X
00641+   10  0  00000              ENA         0
         75  0  00626+             SLJ         CONVERT
00642+   12  0  01063+  SETMOD3X   LDA         LENGTH
         75  0  00626+             SLJ         CONVERT
00643+   11  0  77776   MODE4      INA         -1
         22  1  00645+             AJP     N   MODE5
00644+   12  0  01063+             LDA         LENGTH
         75  0  00626+             SLJ         CONVERT
00645+   11  0  77776   MODE5      INA         -1
         22  1  00651+             AJP     N   MODERR
00646+   36  0  01040+             SSK         X/YFLAG
         75  0  00650+             SLJ         SETMOD5X
00647+   12  0  01063+             LDA         LENGTH
         75  0  00626+             SLJ         CONVERT
00650+   10  0  00000   SETMOD5X   ENA         0
         75  0  00626+             SLJ         CONVERT
00651+   10  0  00000   MODERR     ENA         0
         75  0  00624+             SLJ         MODE0
00652+   75  0  77777   GETTOTAL   SLJ         **
         12  7  01067+             LDA     7   MODEADDR
00653+   22  2  00654+             AJP     P   MODEOCK
         10  0  00000              ENA         0
00654+   22  1  00660+  MODEOCK    AJP     N   MODE1CK
         12  0  01160+             LDA         AMAX
00655+   30  0  01163+             FAD         AMIN
         20  0  01062+             STA         TOTAL
00656+   12  0  01063+             LDA         LENGTH
         31  0  01016+             FSB         =1.0
```

```
00657+  20  0  01063+              STA           LENGTH
        75  0  00652+              SLJ           GETTOTAL
00660+  11  0  77776   MODE1CK     INA           -1
        22  1  00666+              AJP     N     MODE2CK
00661+  12  0  01160+              LDA           AMAX
        31  0  01163+              FSB           AMIN
00662+  22  3  00664+  +           AJP     M     *+2
        12  0  01160+              LDA           AMAX
00663+  30  0  01160+              FAD           AMAX
        75  0  00665+              SLJ           *+2
00664+  12  0  01163+  +           LDA           AMIN
        30  0  01163+              FAD           AMIN
00665+  20  0  01062+  +           STA           TOTAL
        75  0  00652+              SLJ           GETTOTAL
00666+  11  0  77776   MODE2CK     INA           -1
        22  1  00672+              AJP     N     MODE3CK
00667+  10  0  00000               ENA           0
        20  0  01163+              STA           AMIN
00670+  12  0  01160+              LDA           AMAX
        20  0  01062+              STA           TOTAL
00671+  75  0  00652+              SLJ           GETTOTAL
        50  0  00000
00672+  11  0  77776   MODE3CK     INA           -1
        22  1  00702+              AJP     N     MODE4CK
00673+  36  0  01040+  +           SSK           X/YFLAG
        75  0  00677+              SLJ           YMODE3
00674+  10  0  00000   XMODE3      ENA           0
        20  0  01163+              STA           AMIN
00675+  12  0  01160+              LDA           AMAX
        20  0  01062+              STA           TOTAL
00676+  75  0  00652+              SLJ           GETTOTAL
        50  0  00000
00677+  10  0  00000   YMODE3      ENA           0
        20  0  01160+              STA           AMAX
00700+  12  0  01163+              LDA           AMIN
        20  0  01062+              STA           TOTAL
00701+  75  0  00652+              SLJ           GETTOTAL
        50  0  00000
00702+  11  0  77776   MODE4CK     INA           -1
        22  1  00706+              AJP     N     MODE5CK
00703+  10  0  00000               ENA           0
        20  0  01160+              STA           AMAX
00704+  12  0  01163+              LDA           AMIN
        20  0  01062+              STA           TOTAL
00705+  75  0  00652+              SLJ           GETTOTAL
        50  0  00000
00706+  11  0  77776   MODE5CK     INA           -1
        22  1  00716+              AJP     N     MODERROR
00707+  36  0  01040+              SSK           X/YFLAG
```

```
          75  0  00713+            SLJ         YMODE5
00710+    10  0  00000   XMODE5    ENA         0
          20  0  01160+            STA         AMAX
00711+    12  0  01163+            LDA         AMIN
          20  0  01062+            STA         TOTAL
00712+    75  0  00652+            SLJ         GETTOTAL
          50  0  00000
00713+    10  0  00000   YMODE5    ENA         0
          20  0  01163+            STA         AMIN
00714+    12  0  01160+            LDA         AMAX
          20  0  01062+            STA         TOTAL
00715+    75  0  00652+            SLJ         GETTOTAL
          50  0  00000
00716+    10  0  00000   MODERROR  ENA         0
          75  0  00654+            SLJ         MODEOCK
00717+    75  0  77777   ENCODE    SLJ         **
          50  0  00000
00720+    10  0  01030+  +         ENA         =63
          04  0  01055+            ENQ         F.20
00721+    75  4 X00006             RTJ         INGOUT
          50  0  00000
00722+    00  0  01170+  +         ZRO         ITEMP
          00  0  01023+            ZRO         =10
00723+    75  4 X00004   +         RTJ         ERROR
          50  0  00000
00724+    75  4 X00007   +         RTJ         GOUT
          50  0  00000
00725+    00  0  01014+  +         ZRO         =0
          00  0  01072+            ZRO         X/YSCALE
00726+    75  4 X00004   +         RTJ         ERROR
          50  0  00000
00727+    75  4 X00010   +         RTJ         ENDGOUT
          50  0  00000
00730+    75  4 X00004   +         RTJ         ERROR
          50  0  00000
00731+    75  0  00717+  +         SLJ         ENCODE
          50  0  00000
00732+    75  0  77777   ALLZEROS  SLJ         **
          61  0  00734+            SAL         **+2
00733+    07  0  00060             LLS         48
          61  0  00735+            SAL         **+2
1   00734+    12  0  01015+            LDA         =1.0
          20  0  77777             STA         **
00735+    12  0  01015+            LDA         =1
          20  0  77777             STA         **
00736+    75  0  00732+            SLJ         ALLZEROS
          50  0  00000
00737+    75  0  77777    TPCHK    SLJ         **                    CHECK TAPE WRITE
          56  1  00765+            SIU      1  TPE
```

```
       00740+  52  1  00737+           LIU   1  TPCHK
               51  1  77774            INI   1  -3
       00741+  12  1  00000            LDA   1  0
               20  0  00753+           STA      TPPAR2
       00742+  10  0  00060   TP1      ENA      48
               75  4 X00012            RTJ      IFUNIT           CAL IFUNIT TO CHECK WRITE
       00743+  41  0  00770+ +         SCL      IFMSK
               22  3  00742+           AJP   3  TP1
       00744+  22  0  00765+           AJP   0  TPE                  ZRO.  O.K., OUT
               05  0  00001            ALS      1
       00745+  22  3  00756+           AJP   3  TPEOT                BIT 47 NEG.=EOT
               72  0  00767+           RAO      TPCTR            PARITY ERROR
       00746+  22  0  00765+           AJP   0  TPE                  TRY TO REWRITE 3 TIMES
               50  0  00000
       00747+  10  0  01027+ +         ENA      =48                  IF NOT CORRECTED,
               75  4 X00013            RTJ      BKSP                 THEN IGNORE IT
       00750+  75  4 X00015  +         RTJ      ERROR*
               50  0  00000
       00751+  10  0  01015+  TPPAR1   ENA      =1                   REWRITE, TRY 3 TIMES
               04  0  01027+           ENQ      =48
       00752+  75  4 X00005            RTJ      BUFOUT
               50  0  00000
       00753+  00  0  77777   TPPAR2   ZRO      **
               00  0  77777            ZRO      **
       00754+  75  4 X00015            RTJ      ERROR*
               50  0  00000
       00755+  75  0  00742+ +         SLJ      TP1
               50  0  00000
       00756+  05  0  00001   TPEOT    ALS      1                EOT
               22  3  00761+           AJP   3  TPEOTP               LAST RECORD OK
       00757+  10  0  01027+           ENA      =48
               75  4  00771+           RTJ      NEWTAPE              GET NEW TAPE
       00760+  75  0  00765+ +         SLJ      TPE                  OUT
               50  0  00000
       00761+  10  0  01027+  TPEOTP   ENA      =48              EOT WITH BAD PARITY
               75  4 X00013            RTJ      BKSP
       00762+  75  4 X00015  +         RTJ      ERROR*
               50  0  00000
       00763+  10  0  01027+ +         ENA      =48
               75  4  00771+           RTJ      NEWTAPE              GET NEW TAPE
       00764+  75  0  00751+ +         SLJ      TPPAR1               REWRITE LAST RECORD
               50  0  00000
       00765+  50  1  77777   TPE      ENI   1  **
               10  0  77774            ENA      -3               EXIT
       00766+  20  0  00767+           STA      TPCTR                RESET COUNTER TO TRY 3
               75  0  00737+           SLJ      TPCHK
       00767+  77  7  77777   TPCTR    OCT      -3
               77  7  77774
1      00770+  07  7  77777   IFMSK    OCT      07777777777777777
```

```
            77  7  77777

00771+      75  0  77777     NEWTAPE SLJ        **                CALLED WHEN EOT FOUND
            56  1  01005+            SIU     1  NEWTPE                 WRITES DOUBLE END OF FILE
00772+      10  0  01027+            ENA        =48
            75  4 X00011             RTJ        WREOF             WRITE TWO EOFS
00773+      75  4 X00015    +        RTJ        ERROR*
            50  0  00000
00774+      10  0  01027+ +          ENA        =48
            75  4 X00011             RTJ        WREOF
00775+      75  4 X00015    +        RTJ        ERROR*
            50  0  00000
00776+      04  0  00000    +        ENQ        0
            50  0  00000
00777+      75  4 X00014    +        RTJ        WRITE*
            01  0  00060             1          48
01000+      10  0  00000             10         0                 REWIND WITH LOCKOUT
            00  0  00001             ZRO        1
01001+      50  0  00000             NOP
            50  0  00000             NOP
01002+      04  0  00000    +        ENQ        0
            50  0  00000
01003+      75  4 X00014    +        RTJ        WRITE*            TYPE MESAGE
            02  0  00065             2          54
01004+      03  0  01007+ +          3          MESAGE
            00  0  01014+            0          MESAGE+5
01005+      75  4 X00015    +        RTJ        ERROR*
            50  0  00000
01006+      50  1  77777     NEWTPE  ENI     1  **
            76  0  00771+            SLS        NEWTAPE           WAIT FOR NEW TAPE
01007+      45  2  00301     MESAGE  FLX        5-R-EOT TAPE 48, MOUNT NEW TAPE AND START -R-
            04  0  13015
01010+      20  0  46233
            46  0  40703
01011+      34  0  60104
            06  2  03104
01012+      01  3  01520
            04  3  00622
01013+      04  2  40130
            12  0  10445
01014+      00  0  00000   =0        OCT        0
            00  0  00000
01015+      00  0  00000   =1        DEC        1
            00  0  00001
01016+      20  0  14000   =1.0      DEC        1.0
            00  0  00000
01017+      00  0  00000   =2        DEC        2
            00  0  00002
```

```
1
          01020+  20  0  24000   =2.0      DEC       2.0
                  00  0  00000
          01021+  00  0  00000   =8        DEC       8
                  00  0  00010
          01022+  00  0  00000   =9        DEC       9
                  00  0  00011
          01023+  00  0  00000   =10       DEC       10
                  00  0  00012
          01024+  20  0  45000   =10.0     DEC       10.0
                  00  0  00000
          01025+  00  0  00000   =20       DEC       20
                  00  0  00024
          01026+  00  0  00000   =25       DEC       25
                  00  0  00031
          01027+  00  0  00000   =48       DEC       48
                  00  0  00060
          01030+  00  0  00000   =63       DEC       63
                  00  0  00077
          01031+  00  0  00000   =70       DEC       70
                  00  0  00106
          01032+  00  0  00000   =80       DEC       80
                  00  0  00120
          01033+  00  0  00000   =100      DEC       100
                  00  0  00144
          01034+  20  0  76200   =100.0    DEC       100.0
                  00  0  00000
          01035+  00  0  00000   =900      DEC       900
                  00  0  01604
          01036+  37  7  73777   NFLAG     OCT       377737770000000
                  00  0  00000
          01037+  00  0  00000   INFLAG    OCT       37773777
                  37  7  73777
          01040+                 X/YFLAG   BSS       1
          01041+                 O/UFLAG   BSS       1
          01042+  01  0  20304   LABELCEL  BCD       112345678
                  05  0  60710
          01043+  00  0  00000   LABELCYC  OCT       0
                  00  0  00000
          01044+  00  7  70000   MK1       OCT       007700000000000
                  00  0  00000
          01045+  00  0  00000   MK2       OCT       7777
                  00  0  07777
          01046+  77  7  77777   MASK      OCT       777777700000000
                  00  0  00000
          01047+  00  0  00000   LOWMASK   OCT       77700000
                  77  7  00000
          01050+  77  7  77777   CLEARMK   OCT       777777777700000
                  77  7  00000
          01051+  52  5  25252   CONTROL2  OCT       525252525252525
```

```
               52  5  25252
       01052+  52  5  25252   CONTR1    OCT        5252525252525252
               52  5  25252
       01053+  00  0  00000   LOWMARG   DEC        1
               00  0  00001
       01054+  02  0  00000   SCALSIZ   OCT        0200000000000000
               00  0  00000
       01055+  34  6  50112   F.20      BCD        1(E10.2)
               73  0  27420
       01056+  20  2  72061   SCALEX1   BCD        1 X AXIS
               27  7  12220
       01057+  22  6  36143   SCALEX2   BCD        1SCALE =
               65  2  01320
1      01060+  20  3  02061   SCALEY1   BCD        1 Y AXIS
               27  7  12220
       01061+  22  6  36143   SCALEY2   BCD        1SCALE =
               65  2  01320
       01062+  00  0  00000   TOTAL     OCT        0
               00  0  00000
       01063+  00  0  00000   LENGTH    OCT        0
               00  0  00000
       01064+  00  0  00000   WIDTH     OCT        0
               00  0  00000
       01065+  00  0  00000   HEIGHT    OCT        0
               00  0  00000
       01066+  00  0  00000   EXPONENT  OCT        0
               00  0  00000
       01067+  00  0  00000   MODEADDR  OCT        0
               00  0  00000
       01070+  00  0  00000   QUANTA    OCT        0
               00  0  00000
       01071+  00  0  00000   TEMPSCAL  OCT        0
               00  0  00000
       01072+  00  0  00000   X/YSCALE  OCT        0
               00  0  00000
       01073+  00  0  00000   TEMP      OCT        0
               00  0  00000
       01074+  00  0  00000   IOFFS     OCT        0
               00  0  00000
       01075+  00  0  00000   IXOFFS    OCT        0
               00  0  00000
       01076+  00  0  00000   IYOFFS    OCT        0
               00  0  00000
       01077+  00  0  00000   IWIDE     OCT        0
               00  0  00000
       01100+  00  0  00000   LABELX    OCT        0
               00  0  00000
       01101+  00  0  00000   LABELY    OCT        0
               00  0  00000
```

```
    01102+  00  0  00000   XSCALE    OCT        0
            00  0  00000
    01103+  00  0  00000   YSCALE    OCT        0
            00  0  00000
    01104+  00  0  00000   XSCLAB1   OCT        0
            00  0  00000
    01105+  00  0  00000   XSCLAB2   OCT        0
            00  0  00000
    01106+  00  0  00000   YSCLAB1   OCT        0
            00  0  00000
    01107+  00  0  00000   YSCLAB2   OCT        0
            00  0  00000
    01110+  00  0  00000   MODCURV   OCT        0
            00  0  00000
    01111+  00  0  00000   NUMPTS    OCT        0
            00  0  00000
    01112+  00  0  00000   X1ADDR    OCT        0
            00  0  00000
    01113+  00  0  00000   Y1ADDR    OCT        0
            00  0  00000
1   01114+  00  0  00000   SFXADDR   OCT        0
            00  0  00000
    01115+  00  0  00000   SFYADDR   OCT        0
            00  0  00000
    01116+  00  0  00000   IHIGH     OCT        0
            00  0  00000
    01117+  00  0  00000   TITLESIZ  OCT        0
            00  0  00000
    01120+  00  0  00000   T1/2ADDR  OCT        0
            00  0  00000
    01121+  00  0  00000   INTERPS   OCT        0
            00  0  00000
    01122+  00  0  00000   INCRJVL   OCT        0
            00  0  00000
    01123+  00  0  00000   IVH       OCT        0
            00  0  00000
    01124+  00  0  00000   INCRVH    OCT        0
            00  0  00000
    01125+  00  0  00000   NH        OCT        0
            00  0  00000
    01126+  00  0  00000   IVL       OCT        0
            00  0  00000
    01127+  00  0  00000   JVL       OCT        0
            00  0  00000
    01130+  00  0  00000   IVV       OCT        0
            00  0  00000
    01131+  00  0  00000   INCRVV    OCT        0
            00  0  00000
    01132+  00  0  00000   NV        OCT        0
```

```
             00   0   00000
   01133+    00   0   00000   LSVOV     OCT         0
             00   0   00000
   01134+    00   0   00000   IT        OCT         0
             00   0   00000
   01135+    00   0   00000   JT        OCT         0
             00   0   00000
   01136+    00   0   00000   IH        OCT         0
             00   0   00000
   01137+    00   0   00000   JV        OCT         0
             00   0   00000
   01140+    00   0   00000   JH        OCT         0
             00   0   00000
   01141+    00   0   00000   JHL       OCT         0
             00   0   00000
   01142+    00   0   00000   LH        OCT         0
             00   0   00000
   01143+    00   0   00000   IHL       OCT         0
             00   0   00000
   01144+    00   0   00000   INCRIHL   OCT         0
             00   0   00000
   01145+    00   0   00000   IV        OCT         0
             00   0   00000
   01146+    00   0   00000   LV        OCT         0
             00   0   00000
   01147+    00   0   00000   ITOR      OCT         0
             00   0   00000
1  01150+    00   0   00000   LSHOH     OCT         0
             00   0   00000
   01151+    00   0   00000   IPT       OCT         0
             00   0   00000
   01152+    00   0   00000   JPT       OCT         0
             00   0   00000
   01153+    00   0   00000   BUFAD     OCT         0
             00   0   00000
   01154+    00   0   00000   KTITLE    OCT         0
             00   0   00000
   01155+    00   0   00000   LABEL     OCT         0
             00   0   00000
   01156+    00   0   00000   XMAX      OCT         0
             00   0   00000
   01157+    00   0   00000   AXMAX     OCT         0
             00   0   00000
   01160+    00   0   00000   AMAX      OCT         0
             00   0   00000
   01161+    00   0   00000   XMIN      OCT         0
             00   0   00000
   01162+    00   0   00000   AXMIN     OCT         0
             00   0   00000
```

```
          01163+  00  0  00000   AMIN      OCT        0
                  00  0  00000
          01164+  00  0  00000   YMAX      OCT        0
                  00  0  00000
          01165+  00  0  00000   AYMAX     OCT        0
                  00  0  00000
          01166+  00  0  00000   YMIN      OCT        0
                  00  0  00000
          01167+  00  0  00000   AYMIN     OCT        0
                  00  0  00000
          01170+                 ITEMP     BSS        15
          01207+                 STORE     BSS        460
                                           END
             NO DOUBLY DEFINED
             NO UNDEFINED SYMBOLS
             NO ERRORS
                NULLS                     CALCVALS           XMODE3          XMODE5             =80
                         00000             END       PLOTEST
 EXECUTE,100,56,0.
1 PROGRAM NAMES
0 00000 RESIDENT                        02002 ERRDUMP*                          72252 PLOTEST
  70677 GOUT                            70625 ERROR                             70602 FORTNTRY
  70530 FORTFLGS                        66405 GRAFPLOT                          66374 FLOATF
  66323 XTOI                            66257 XINTF                             66114 BUFINOUT
  66073 WRITEEOF                        66022 BACKSPAS
0 LABELED COMMON       NONE
0 NUMBERED COMMON      NONE
0 PROGRAM ENTRY POINTS
0 01205 READ*                           01212 WRITE*                            00655 SELECT*
  01140 REMOVE*                         00743 DETECT*                           01760 GETCH*
  01765 CHKSTD*                         03044 LOADER*                           03045 RELOCOM*
  02735 LIBREW*                         02654 CLBNBCD*                          02613 EXIT*
  01774 ERROR*                          01174 MODIRET*                          00401 BCDBN*
  00335 OPCOM*                          02227 RECRET*                           02246 RECLIM*
  00524 FLAGTST*                        00217 MEMREC*                           01737 CBF*
  01740 CBF1*                           01741 CBF2*                             01746 CBF7*
  00714 IOSLECT*                        01470 MRW600*                           05322 LOK1*
  04730 LMSRCH*                         01121 ILMF*                             01747 FCH*
  01034 EXSEN*                          00167 SETCLK*                           00076 DATE*
  00061 SIEOF                           02727 LIBPOSIT                          72252 PLOTEST
  70677 INGOUT                          71144 GOUT                              71123 ENDGOUT
  70625 ERROR                           70650 ERROR2                            66427 GRAFPLOT
  70602 FORTNTRY                        70605 FORTEXIT                          70621 FORTGIN
  70622 FORTGOUT                        70530 FSETEOFS                          70533 FSETIOCK
  70536 FSETTAPE                        70555 FSENEOFS                          70561 FSENIOCK
  70565 FSENTAPE                        66405 AUTOGRAF                          66404 FLOATF
  66323 XTOI                            66257 XINTF                             66114 BUFIN
  66120 BUFOUT                          66230 IFUNIT                            66073 WREOF
  66022 BKSP
```

```
      PROGRAM SORT (IA, IB, IC, ID, IE, IF)

*     LAST CORRECTED 30 MARCH 1963,  R.L. HOGG
*     NOTE -- THIS PROGRAM IS FOR TYPEWRITER CALL


      LOC(BCDTYPE=25, LOCK=33)
      HOL(FINISH0= SORTED ,FINISH1=OUTPUT I,FINISH2=S ON TAP,
     *    FINISH3=E NR.     )
      CON(MKSOUT=7777777777770000B)
      CON(ERROR=2020714547242320B,ERROR1=6151672065515146B,
     *    ERROR2=5100000000000000B)
      ENA(IA)          STA(ICOL)        .
      ENA(IB)          STA(IICOL)       .
      ENA(IC)          STA(INPUT)       .
      ENA(ID)          STA(ITAPE)       .
      ENA(IE)          STA(IITAPE)      .
      ENA(IF)          STA(LISTOUT)     .
      EXF(62540B)      SLJ1(12)         . LOCKOUT SAT. / JK1 , GO DUMP
      IF(ICOL-IICOL) 8,8,13
 8    LAST=IICOL
 9    INCR=6
 10   INIT=LAST-INCR
      IF(INIT-ICOL) 11,12,12
 11   INCR=INCR-1
      GO TO 10
 12   CALL SORT7 (INIT,LAST,INPUT,ITAPE,IITAPE,LISTOUT)
      IF(INIT-ICOL) 13,15,14
 13   ENA(ERROR)       SLJ4(BCDTYPE)    .
      GO TO 16
 14   INPUT=LISTOUT
      LAST=INIT-1
      GO TO 9
 15   LDA(LOCK)        INA(1)           . GET ADDRESS FOR LOCK ARG
      SAL(L+1)         ENI(0)           .
      LDA(LISTOUT)     STA(N)           . SET LOCK ARG
      SLJ4(LOCK)       ZRO(0)           .
      LDA(LISTOUT)     ALS(6)           .
      LDQ(MKSOUT)      SSU(FINISH3)     .
      STA(FINISH3)     ENA(FINISH0)     .
      SLJ4(BCDTYPE)    ZRO(0)           .
 16   END


      SUBROUTINE SORT7 (ICOL,IICOL,INPUT,NFLAG3,NFLAG4,LISTOUT)
C     SORT7  CAN ONLY SORT ON SEVEN COLUMNS AT A TIME
C     ICOL = LOWEST NR. COLUMN OF FIELD
```

```
C      IICOL = HIGHEST NR. COLUMN OF FIELD, MAX FIELD WIDTH = 7
C      NFLAG1 = LAST BLOCK KEY WORD COUNT
C      NFLAG2 = RUNNING TOTAL OF NR. OF BLOCKS ON MERGED TAPE
C      NFLAG3 = TAPE NR. WHICH HOLDS MERGED FILE
C      NFLAG4 = TAPE NR. ON WHICH TO ORDER NEXT MERG
       SLJ1(400)
       NFLAG1 = -0
       NFLAG2 = 0
       REWIND INPUT
       REWIND NFLAG3
       REWIND NFLAG4
       REWIND LISTOUT
       NRCOLS=IICOL-ICOL+1
       IF(NRCOLS-7) 100,100,99
   99  STOP
  100  CALL ALSINP(ICOL,IICOL,INPUT)
       ALS(33)          ARS(33)          . EXTEND SIGN BIT
       STA(NFLAG1)      AJP3(200)        .
       AJP(260)
  200  CALL RLHMERG (NFLAG1)
       IF(NFLAG2) 250,250,300
  250  CALL WRITE (NFLAG3,37000B,57000B,1)
       NFLAG2 = 1
       REWIND NFLAG3
       LDA(NFLAG1)    AJP3(100)
       SLJ(400)
  260  NFLAG2=NFLAG2+1
       SLJ(400)
  300  CALL HEXSORT(NFLAG1,NFLAG2,NFLAG3,NFLAG4)
       NFLAG2 = NFLAG2 + 1
       ITEMP = NFLAG3
       NFLAG3 = NFLAG4
       NFLAG4=ITEMP
       REWIND NFLAG3
       REWIND NFLAG4
       LDA(NFLAG1)    AJP3(100)
  400  REWIND INPUT
       REWIND NFLAG4
       CALL KREMKEY(NFLAG1,NFLAG2,NFLAG3,LISTOUT)
       END


       MACHINE RDMT(1ARG,2ARG,3ARG,4ARG,5ARG,6ARG)

* NOTE  G = ADDRESS OF ENTRY TO TYPEWRITER SENSE ROUTINE
*       P = ADDRESS OF PROGRAM CONTROL ROUTINE JUMP  ENTRY
* THIS ROUTINE IS FOR PROGRAM CALL
```

```
      LOC(G=31,  P=10)

* TYPEWRITER MESSAGE CODE TABLE

      CON(T6 =4504041220302204B,  T7 =1120061301050420B,
     *    T8 =1212031200000000B,  T9 =4504041220302204B,
     *    T10=1530121401250420B,  T11=1212031200000000B)
      CON(T12=4504041220302204B,  T13=2006220403260426B,
     *    T14=1411200000000000B,  T15=4504043112140120B,
     *    T40=4504040130152004B,  T41=3406140104060301B,
     *    T42=0414062214163001B,  T43=2022420000000000B)

* TAPE UNIT ASSIGNMENT TABLE
*     ASSIGNMENTS FOR CHANNEL 3/4 LIBRARY TAPE

      CON(K0 =0      ,  K1 =332010B,  K2 =332020B,
     *    K3 =332030B,  K4 =332040B,  K5 =552010B,
     *    K6 =552020B,  K7 =552030B,  K8 =552040B)

* ASSORTED CONSTANTS

      CON(R4 =7373737373737373B,  R16=0070000000000000B)

* TAPE READING ROUTINE

1X    SLJ(N)            SLJ(L+7)         . EXIT/ENTRY
1ARG  ZRO(0)            ZRO(0)           . TAPE UNIT NUMBER ARG.
2ARG  ZRO(0)            ZRO(0)           . INITIAL ADDRESS
3ARG  ZRO(0)            ZRO(0)           . TERMINAL ADDRESS
4ARG  ZRO(0)            ZRO(0)           . MODE, 1 = BINARY, 2 = BCD
5ARG  ZRO(0)            ZRO(0)           .
6ARG  ZRO(0)            ZRO(0)           . ENDFILE EXIT ADDRESS LOCATOR
      LDA(5ARG)         SAU(22X)         .
      LDA7(6ARG)        SAL(23X)         .
      SIU1(23X)         ENI(0)           .
      LDA7(1ARG)        INA(-11B)        .
      SIU1(20X)         AJP3(L+3)        . CHECK FOR TU ASSIGNMENT
      ENA(T40)          SLJ4( G)         . GO PRINT ERROR
      SLJ( P)           ZRO(0)           .
      INA(11B)          STA(K0)          .
      LIL1(K0)          LDA1(K0)         .
      ADD7(4ARG)        SAU(4X)          . SET TU CONTROL CODES
      SCL(777B)         SAL(4X)          . INITIALIZE
      SAL(5X)           SAL(11X)         .
```

```
         INA(3)          SAU(8X)         .
         INA(2)          SAU(9X)         .
         INA(1)          SAU(11X)        .
         INA(1)          SAU(7X)         .
         LRS(18)         ENA(0)          .
         LLS(3)          SAL(2X)         .
         SAL(3X)         SAU(12X)        .
         LLS(39)         LDQ(R15)        .
         STA(KO)         LDA(5X)         .
         SSU(KO)         STA(5X)         .
         LDA7(2ARG)      SAU(5X)         .
         LDA(6X)         SSU(KO)         .
         STA(6X)         ENI(0)          .
2X       LDA7(3ARG)      SAL(N)          .
         SAU(6X)         SIU2(19X)       .
3X       ENI2(4)         LIL1(N)         .
4X       EXF(N)          EXF7(N)         . SELECT UNIT
5X       EXF(N)          EXF7(N)         . ACTIVATE CHANNEL
6X       EXF(N)          LDA7(2ARG)      .
         SUB(R4)         LLS(48)         .
         INI1(-1)        LDA1(Z)         .
         INI1(1)         SUB(R4)         .
7X       EXF7(N)         SLJ(21X)        . SENSE ENDFILE
8X       EXF7(N)         SLJ(L+4)        . SENSE PARITY ERROR
9X       EXF7(N)         SLJ(10X)        . SENSE LENGTH ERROR
         QJP1(19X)       AJP(3X)         . SENSE FOR BAD RECORD
         SLJ(19X)        ZRO(0)          . EXIT
         IJP2(L+2)       SLJ(14X)        . SENSE FIVE PARITY ERRORS
10X      IJP2(L+1)       SLJ(13X)        . SENSE FIVE LENGTH ERRORS
         AJP(3X)         QJP(3X)         . SENSE FOR BAD RECORD
11X      EXF(N)          EXF7(N)         . BACKSPACE
12X      LIL1(N)         SLJ(4X)         . RETURN TO REREAD
13X      ENA(T6)         SLJ(17X)        . SET TO INDICATE TROUBLE
14X      ENA(T9)         SLJ(17X)        .
15X      ENA(T12)        SLJ(18X)        .
17X      SLJ4( G)        ZRO(0)          . TROUBLE EXIT
         AJP(19X)        AJP3(3X)        . SENSE ACTION TO TAKE
         SLJ(11X)        ZRO(0)          .
18X      SLJ4( G)        ZRO(0)          . TROUBLE EXIT
         AJP(3X)         AJP3(3X)        . SENSE ACTION TO TAKE
         SLJ(11X)        ZRO(0)          .
19X      ENI2(N)         ENI(0 )         . RE-STORE INDEXES
20X      ENI1(N)         SLJ(1X)         .
21X      LIU2(L-2)       INI2(-1)        .
22X      SIL2(N)         ENI2(512)       .
23X      ENI1(N)         SLJ(N)          . ENDFILE DETECTED/EXIT
         END
```

```
SUBROUTINE ALSINP(ICOL,IICOL,INPUT)
LOC(INT=00005, TYPE=31)
CON(MSK1=4000000000000000B)
CON(ERR0 =4504044714111120B,      ERR1 =1330110423162204B)
CON(ERR2 =2425072303110414B,      ERR3 =0616033406012012B)
CON(ERR4 =2022404504042434B,      ERR5 =2324011401342220B)
CON(ERR6 =2204300462420404B,      ERR7 =1512202424041612B)
CON(ERR10=0401030416030501B,      ERR11=1406342042570000B)
CON(BCD0 =5353535353535353B,      BCD1 =7474747474747474B)
CON(BCD2 =3434343434343434B,      BCD3 =1414141414141414B)
CON(BCD4 =3333333333333333B,      BCD5 =2121212121212121B)
CON(BCD6 =1313131313131313B,      BCD7 =6060606060606060B)
CON(BCD10=4040404040404040B,      BCD11=5454545454545454B)
CON(BCD12=7373737373737373B,      BCD13=3131313131313131B)
CON(BCD14=3030303030303030B,      BCD15=2727272727272727B)
CON(BCD16=2626262626262626B,      BCD17=2525252525252525B)
CON(BCD20=2424242424242424B,      BCD21=2323232323232323B)
CON(BCD22=2222222222222222B,      BCD23=5151515151515151B)
CON(BCD24=5050505050505050B,      BCD25=4747474747474747B)
CON(BCD26=4646464646464646B,      BCD27=4545454545454545B)
CON(BCD30=4444444444444444B,      BCD31=4343434343434343B)
CON(BCD32=4242424242424242B,      BCD33=4141414141414141B)
CON(BCD34=7171717171717171B,      BCD35=7070707070707070B)
CON(BCD36=6767676767676767B,      BCD37=6666666666666666B)
CON(BCD40=6565656565656565B,      BCD41=6464646464646464B)
CON(BCD42=6363636363636363B,      BCD43=6262626262626262B)
CON(BCD44=6161616161616161B,      BCD45=1111111111111111B)
CON(BCD46=1010101010101010B,      BCD47=0707070707070707B)
CON(BCD50=0606060606060606B,      BCD51=0505050505050505B)
CON(BCD52=0404040404040404B,      BCD53=0303030303030303B)
CON(BCD54=0202020202020202B,      BCD55=0101010101010101B)
CON(BCD56=1212121212121212B,      BCD57=2020202020202020B)
CON(ORD0 =5757575757575757B,      ORD1 =5656565656565656B)
CON(ORD2 =5555555555555555B,      ORD3 =5454545454545454B)
CON(ORD4 =5353535353535353B,      ORD5 =5252525252525252B)
CON(ORD6 =5151515151515151B,      ORD7 =5050505050505050B)
CON(ORD10=4747474747474747B,      ORD11=4646464646464646B)
CON(ORD12=4545454545454545B,      ORD13=4444444444444444B)
CON(ORD14=4343434343434343B,      ORD15=4242424242424242B)
CON(ORD16=4141414141414141B,      ORD17=4040404040404040B)
CON(ORD20=3737373737373737B,      ORD21=3636363636363636B)
CON(ORD22=3535353535353535B,      ORD23=3434343434343434B)
CON(ORD24=3333333333333333B,      ORD25=3232323232323232B)
CON(ORD26=3131313131313131B,      ORD27=3030303030303030B)
CON(ORD30=2727272727272727B,      ORD31=2626262626262626B)
CON(ORD32=2525252525252525B,      ORD33=2424242424242424B)
CON(ORD34=2323232323232323B,      ORD35=2222222222222222B)
CON(ORD36=2121212121212121B,      ORD37=2020202020202020B)
```

```
     CON(ORD40=1717171717171717B,      ORD41=1616161616161616B)
     CON(ORD42=1515151515151515B,      ORD43=1414141414141414B)
     CON(ORD44=1313131313131313B,      ORD45=1212121212121212B)
     CON(ORD46=1111111111111111B,      ORD47=1010101010101010B)
     CON(ORD50=0707070707070707B,      ORD51=0606060606060606B)
     CON(ORD52=0505050505050505B,      ORD53=0404040404040404B)
     CON(ORD54=0303030303030303B,      ORD55=0202020202020202B)
     CON(ORD56=0101010101010101B,      ORD57=0000000000000000B)
     ENA(1EFX)          STA(ENDFILE)    .
     ENA(-0)            STA(SWITCH)     .
     STA(SLK1)
     ENA(17000B)        STA(KEY)        .
     INA(1)             STA(INIT)       .
     SAU(2WHL)          SAU(2TRU)       .
     INA(17B)           STA(ITERM)      .
1CKK SIU2(2STI)       ENI2(1)          .SAVE B2 AND SET TO ONE
     LDA(IICOL)       SUB(ICOL)        .WINDOW SHIFTS
     SAU(2CNV)        SIL6(2STI)       .
     INA(1)           MUI(6)           .SHIFT COUNT =6XNO. CHAR
     SAL(2CKK)        ENQ(-0)          .ALL ONES TO Q
2CKK ENA(0)           LLS(N)           .CLEAR A AND SHIFT AQ LEFT TO
     STQ(MSK2)        ENQ(0)           .FORM MASK FOR SELECTIVE CLEARING
     LDA(ICOL)        DVI(8)           .
     QJP1(L+1)          STQ(SWITCH)     .
     STA(TMP1)        LDA(IICOL)       .CHECK BOTH ENDS OF EKEY
     ENQ(0)                            .SET UP AQ FOR ANOTHER DVI
     DVI(8)           STQ(TMP2)        .
     SUB(TMP1)        AJP1(1SPL)       .JUMP IF KEY IS IN TWO WORDS
     SSK(SWITCH)        SLJ(1TRU)       .
1WHL ENA(8)           SUB(TMP2)        .EIGHT MINUS R2
     MUI(6)           SAL(3WHL)        .PLACE SHIFT COUNT
2WHL ENA(N)           ADD(TMP1)        .GET ADDRESS OF WORD WITH KEY
     SAU(3WHL)        ENI(0)           .RETURN JUMP TO READ NEXT RECORD
     CALL RDMT(INPUT,INIT,ITERM,2,SLK1,ENDFILE)
3WHL LDA(N)           ARS(N)           .RIGHT JUSTIFY KEY
     SLJ4(1CNV)                        .RETURN JUMP TO CONVERT KEY
     SLJ(2WHL)                         .PREPARE FOR NEXT RECORD
1SPL LDA(TMP2)        AJP1(1TRJ)       .KEY REALLY SPLIT
     ENA(8)           STA(TMP2)        .CHANGE R2 TO EIGHT
     SLJ(1WHL)                         .KEY NOT SPLIT AFTER ALL
1TRU ENA(6)           MUI(TMP2)        .SIX TIMES R2
     SAU(4TRU)                         .PLACE SHIFT COUNT FOR LLS
2TRU ENA(N)           ADD(TMP1)        .COMPUTE CELL WITH START KEY
     SAU(3TRU)        INA(1)           .CELL WITH ENDKEY
     SAL(3TRU)        ENI(0)           .RETJUMP TO READ NEXT RECORD
     CALL RDMT(INPUT,INIT,ITERM,2,SLK1,ENDFILE)
3TRU LDA(N)           LDQ(N)           .KEY TO AQ , RIGHT JUSTIFY IN A
4TRU LLS(N)           SLJ4(1CNV)       .RETJUMP TO CONVERT KEY
     SLJ(2TRU)                         .PREPARE FOR NEXT RECORD
```

```
 1CNV SLJ(N)              SIL3(3STI)        .
 2CNV ENI3(N)             SCL(MSK2)         .
      STA(TEMPKEY)        ENQ(773)          .
1LOOP  LDL(TEMPKEY)       ENI6(60B)         .
      MEQ6(BCDO)          SLJ(1ERR)         .
      LDA(TEMPKEY)        SSU6(ORDO)        .
      STA(TEMPKEY)        QLS(6)            .
 3STI IJP3(1LOOP)         ENI3(N)           .
      LDA(TEMPKEY)        ENI(0)            .
      SCM(MSK1)           STA7(KEY)         . COMPLIMENT 48TH BIT
      ENA(20B)            RAD(KEY)          .
      INA(1)              SAL(INIT)         .
      SAU(2WHL)           SAU(2TRU)         .
      INA(17B)            SAL(ITERM)        .
1EFX  ISK2(512)           SLJ(1CNV)         .
 2STI ENI2(N)             ENI6(N)           .
      LDA(SLK1)           ENI(0)            .
      RETURN
 1ERR SIU1(L+4)           STQ(TEMPQ)        .
      LDA(TEMPKEY)        SSU(BCDO)         .
      STA(TEMPKEY)        ENA(ERRO)         .
      SLJ4(TYPE)          ZRO(0)            .
      ENI1(N)             LDQ(TEMPQ)        .
      QLS(6)              SLJ(3STI)         .
      END



      MACHINE RLHMERG (1A)
      RSV(RA=3B, VA=11B)
      LOC(ABIN=17000, BBIN=37000)
      CON(KA=20B, KA1=17000B, KA2=20000B,
    *     KA3=37000B, KA4=3777777777777777B)
1AA   SLJ(N)              SLJ(L+2)        . EXIT/ENTRY
      ZRO(0)              ZRO(0)          . NFLAG1
      LDA7(L-1)           STA(VA)
1BA   SIU1(RA)            ENI1(0)         . SAVE
      SIL2(RA)            ENI2(0)         .     INDEXES
      SIU3(RA+1)          ENI3(0)         .         AND
      SIL4(RA+1)          ENI4(0)         .             SET
      SIU5(RA+2)          ENI5(0)         .                 TO
      SIL6(RA+2)          ENI6(0)         .                     ZERO
      LDA(KA1)            STA(VA+1)       . ALPHA = 17,000B
      LDA(KA3)            STA(VA+2)       . BETA = 37,000B
      LDA(KA)             STA(VA+3)       . ORDSIZE = 20B
      LDA(KA2)            STA(VA+4)       . ALTERNATING SIGNED 20,000 = (+)
      LDA(VA)             AJP3(13C)       . TEST NFLAG1, IF NEG. GO TO CYCLE
*     LASTBLC
1BB   MUI(KA)             STA(VA+7)       . CALC NR. OF WORDS IN LASTBLC
```

```
        LIL6(VA+7)        ENI(0)          . SET B6=TOTAL NR.                          03420
        LDA(KA4)          STA6(A3IN)      .    MODIFY                                 03430
        INI6(20B)         SIL6(VA+10B)    .       EXCESSIVE                           03440
        LDA(VA+10B)       SUB(KA2)        .          KEYS IN                          03450
        AJP3(1BB+2)       ENI(0)          .             BLOCK                         03460
*       CYCLE                                                                         03470
1BC     LDA(VA+2)         SAL(2BJ)        . SET FIRST ADDRESS THIS CYCLE              03480
        LDA(VA+1)         STA(VA+5)       . SET FIRSTL = ALPHA                        03490
        LDA(VA+3)         INA(77776B)     . GENERATE ORDSIZE - 1                      03500
        SAU(4BF)          SAU(4BN)        . SET(ORDSIZE) IN STOR,RRUNOUT              03510
        SAU(4BG)          SAU(4BM)        . SET(ORDSIZE) IN STORL AND LRUNOUT         03520
*       PRE MERG                                                                      03530
1BD     LDA(VA+5)         SAU(1BE)        . SET FIRSTL ADDRESS IN MERG                03540
        ADD(VA+3)         STA(VA+6)       . GENERATE FIRSTR ADDRESS                   03550
        SAL(1BE)          LDQ2(VA+6)      . SET FIRSTR ADDRESS IN MERG                03560
*       MERG                                                                          03570
1BE     LDA1(N)           SUB2(N)         . SUBTRACT CURRENT KEYR FROM KEYL           03580
        AJP(1BF)          ENI(0)          . IF DIFF IS ZERO, GO STORL                 03590
        AJP2(1BG)         SLJ(1BF)        . IF DIFF IS (+) GO TO STORR,               03600
*                                         . IF(-) GO TO STORL                         03610
*       STORL                                                                         03620
1BF     LDA(VA+5)         INA1(0)         . GENERATE ADDRESS OF KEYL                  03630
        SAU(2BJ)          SLJ4(13J)       . SET ADDR OF KEYL IN (STORE),              03640
*                                           RETURN JUMP TO (STORE)                    03650
        INI1(17B)         ENI(0)          . INCREASE INDEX 1 BY 17B                   03660
4BF     ISK1(N)           SLJ(1BE)        . IF B1=ORDSIZE-1, ZERO B1,EXIT             03670
*                                           IF NOT, B1 = B1 + 1 GOTO MERG             03680
        SLJ(1BM)          ZRO(0)          . COMPLETE STORAGE OF RIGHT LIST            03690
*       STORR                                                                         03700
1BG     LDA(VA+6)         INA2(0)         . GENERATE ADDRESS OF KEYR                  03710
        SAU(2BJ)          SLJ4(13J)       . SET ADDR KEYR IN (STORE)RJ(STORE)         03720
        INI2(17B)         ENI(0)          . INCREASE B2, 17B                          03730
4BG     ISK2(N)           SLJ(1BE)        . IF B2=ORDSIZE-1,ZERO B2                   03740
*                                           IF NOT, B2=B2+1, GO TO MERG               03750
        SLJ(1BN)          ZRO(0)          . COMPLETE STORAGE LEFT LIST                03760
*       NEW PAIR                                                                      03770
1BH     LDA(VA+3)         ADD(VA+3)       . GENERATE PAIR SIZE                        03780
        ADD(VA+5)         STA(VA+5)       . GEN/SET ADDR OF FIRSTL                    03790
        ENI1(0)           ENI2(0)         . ZERO B1 AND B2                            03800
        SLJ(1BD)          ENI(0)          . GO TO PRE-MERG                            03810
*       RE-CYCL                                                                       03820
1BI     LDA(VA+1)         ADD(VA+4)       . ALPHA= ALPHA (+) OR (-) 20,000B           03830
        STA(VA+1)         LAC(VA+4)       . COMPLIMENT (+) OR (-) 20,000B             03840
        STA(VA+4)         RAD(VA+2)       . BETA = BETA (+) OR (-) 20,000B            03850
        LDA(VA+3)         RAD(VA+3)       . DOUBLE ORDSIZE                            03860
        ISK5(10B)         SLJ(1BC)        . EXIT IF MERG COMPLETE                     03870
*                                           IF NOT GO TO CYCLE                        03880
        SLJ(1BK)          ZRO(0)          . GO TO (EXIT)                              03890
*       STORE                                                                         03900
```

```
1BJ     SLJ(N)            ENI3(0)        . ENTRY/EXIT,  ZERO B3
2BJ     LDA3(N)           STA4(N)        . STORE KEY AND
        INI4(1)           ENI(0)         .    TRAILER WORDS
        ISK3(17B)         SLJ(1BJ+1)     .       AT END OF MERGED LIST
        INI4(77776B)      ENI(0)         . INCREASE B1 BY (-1)
        ISK4(17777B)      SLJ(1BJ)       . IF BLC PROCESS COMPLETE GO TO
*                                             (RE-CYCLE)/ IF NOT COMPLETE IT
        ENI1(0)           ENI2(0)        . ZERO  B1, B2
        SLJ(1BI)          ZRO(0)         . JUMP TO RE-CYCL
*       EXIT
1BK     LDA(VA)           AJP2(13L)      . NFLAG1=-0,IF NOT GOTO(FINAL EXIT)
        LIU1(RA)          LIL2(RA)       . RESET
        LIU3(RA+1)        LIL4(RA+1)     .    ALL
        LIU5(RA+2)        LIL6(RA+2)     .       B - BOXES
        SLJ(1AA)          ZRO(0)         . EXIT FROM S.R. RLHMERG
*       FINAL EXIT
1BL     LDA(KA2)          SUB(VA+7)      . DETERMINE NR. OF NULL CELLS
        STA(VA+7)         LIL6(VA+7)     . SET B6=NR. OF NULL CELLS
        ENI1(0)           ENI(0)         . SET B1=0
        LDA6(BBIN)        ENI(0)         . RELOCATE VALID CELLS
        STA1(BBIN)        INI1(1)        .    TO LOWER STORAGE AT 30,000B
        ISK6(17777B)      SLJ(1BL+3)     . WHEN COMPLETE, JUMP TO RESTORE
        LDA(VA)           SLJ(1BK+1)     .    SECTION OF (EXIT)
*       RRUNOUT
1BM     LDA(VA+6)         INA2(0)        . GENERATE ADDRESS OF KEYR
        SAU(2BJ)          SLJ4(13J)      . SET ADDR KEYR IN (STORE)RJ(STORE)
        INI2(17B)         ENI(0)         . INCREASE B2, 17B
4BM     ISK2(0)           SLJ(1BM)       . IF B2=ORDSIZE-1,ZERO B2
        SLJ(1BH)          ENI(0)         . IF NOT, B2=B2+1, GO TO NEW PAIR
*       LRUNOUT
1BN     LDA(VA+5)         INA1(0)        . GENERATE ADDRESS OF KEYL
        SAU(2BJ)          SLJ4(1BJ)      . SET ADDR OF KEYL IN (STORE),
*                                          RETURN JUMP TO (STORE)
        INI1(17B)         ENI(0)         . INCREASE INDEX 1 BY 17B
4BN     ISK1(0)           SLJ(1BN)       . IF B1=ORDSIZE-1, ZERO B1,EXIT
        SLJ(1BH)          ZRO(0)         . IF NOT, B1 = B1 + 1 GOTO NEW PAIR
        END



        SUBROUTINE HEXSORT(NFLAG1,NFLAG2,NFLAG3,NFLAG4)
        LOC(ABIN=17000,BBIN=37000,CBIN=57000)
        CON(TWENTY=20B)
        SIU1(STOR1)     SIL2(STOR1)      .SAVE
        SIU3(STOR2)     SIL5(STOR2)      .   B - BOXES
        SIU6(STOR3)     ENI1(1)          .       SET B-BOXES
        ENI2(0)         ENI3(0)          .          TO ZERO
        ENI5(0)         ENI6(1)          .
        ENA(20000B)     SAU(2MERG)       .PRIME SUBROUTINE
```

```
      LDA(NFLAG2)    SAU(1C)           .
      SAU(1TEST)     ENI(0)            .
      SLJ4(1RD)      ENI(0)            .
      LDA(NFLAG1)    AJP3(1A)          .INSPECT IF LAST BLOCK
      MUI(TWENTY)    SAU(2MERG)        .SET LAST BLOCK PARAMETER
   1A INI1(-1)       ENI(0)            .
      LDA1(ABIN)     SUB2(BBIN)        .MERG ONE KEY
      AJP(1ASML)     ENI(0)            .
      AJP2(1BSML)    SLJ(1ASML)        .   AND TRAILER
2MERG ISK2(20000B)   SLJ(1CONT)        .IS BBIN EMPTY
      ISK1(20000B)   SLJ4(1DUMP)       .IS ABIN EMPTY
   1C ISK6(N)        SLJ(1PROC)        .IS READ TAPE EMPTY
      SLJ(2TEST)     ENI(0)            .SERVICE CBIN PRIOR TO EXIT
1PROC SLJ4(1RD)      ENI(0)            .PROCESS OUT
      ENI1(1)        SLJ4(1DUMP)       .   REST OF
      SLJ(1C)        ENI(0)            .      READ TAPE
1CONT INI2(-1)       ENI(0)            .
      ISK1(20000B)   SLJ(1A)           .IS ABIN EMPTY
1TEST ISK6(N)        SLJ(1READ)        .IS READ TAPE EMPTY
      SLJ4(2DUMP)    ZRO(0)            .
2TEST LDA(NFLAG1)    AJP3(1END)        .IS BBIN LAST BLOCK
      LDA(NFLAG1)    INA(-1000B)       .
      AJP(1END)      SLJ4(1WRT)        .WAS LAST BLOCK,FULL SIZE
      SLJ(1END)      ENI(0)            .
20TCB SLJ(N)         ENI(0)            .CBIN STORAGE
      LDA5(N)        STA3(CBIN)        .   ROUTINE
      INI3(1)        ENI(0)            .      AND AUTOMATIC
      ISK5(17B)      SLJ(20TC3+1)      .         WRITE-OUT
      INI3(-1)       ENI(0)            .            WHEN FULL
      ISK3(17777B)   SLJ(20TCB)        .
      SLJ4(1WRT)     ENI(0)            .
      SLJ(20TCB)     ENI(0)            .
  1RD SLJ(N)         ENI(0)            .READ ROUTINE
      CALL READ (NFLAG3,17000B,37000B,1)
      SLJ(1RD)       ENI(0)            .
 1WRT SLJ(N)         ENI(0)            .WRITE ROUTINE
      CALL WRITE(NFLAG4,57000B,77000B,1)
      SLJ(1WRT)      ENI(0)            .
1ASML ENA1(ABIN)     SAU(20TC3+1)      .TRANSFER KEY
      SLJ4(20TCB)    ENI(0)            .   FROM ABIN
      INI1(20B)      SLJ(2MERG)        .      TO CBIN
1BSML ENA2(BBIN)     SAU(20TC3+1)      .TRANSFER KEY
      SLJ4(20TCB)    ENI(0)            .   FROM BBIN
      INI2(20B)      SLJ(2MERG)        .
1DUMP SLJ(N)         INI1(-1)          .TRANSFER
      ENA1(ABIN)     SAU(20TC3+1)      .   REMAINING
      SLJ4(20TCB)    ENI(0)            .      KEYS FROM
      INI1(17B)      ENI(0)            .         ABIN TO
      ISK1(17777B)   SLJ(1DUMP+1)      .            CBIN
```

```
      SLJ(1DUMP)       ENI(0)               .
2DUMP SLJ(N)           ENI(0)               .TRANSFER
      ENA2(BBIN)       SAU(20TCB+1)         .   REMAINING
      SLJ4(20TCB)      ZRO(0)               .      KEYS FROM
      INI2(17B)        ENI(0)               .         BBIN TO
      ISK2(17777B)     SLJ(2DUMP+1)         .            CBIN
      SLJ(2DUMP)       ZRO(0)               .
1READ SLJ4(1RD)        ENI(0)               .NON-RETURN JUMP
      ENI1(1)          SLJ(1A)              .   READ ROUTINE
 1END LIU1(STOR1)      LIL2(STOR1)          .
      LIU3(STOR2)      LIL5(STOR2)          .
      LIU6(STOR3)      ENI(0)               .
      END



      SUBROUTINE KREMKEY(NFLAG1,NFLAG2,NFLAG3,LISTOUT)
      REWIND LISTOUT
      REWIND NFLAG3
      NFLAG22=NFLAG2
   50 NFLAG22=NFLAG22-1
      IF(NFLAG22) 200,200,100
  100 CALL READ(NFLAG3,17000B,37000B,1)
      DO 10 I = 1,512
      INIT = 16761B + 20B*I
      NTERM = 17000B + 20B * I
      CALL WRITE(LISTOUT,INIT,NTERM,2)
   10 CONTINUE
      GO TO 50
  200 IF(NFLAG1) 20,20,201
  201 CALL READ(NFLAG3,17000B,37000B,1)
      DO 20 I = 1,NFLAG1
      INIT = 16761B+20B*I
      NTERM = 17000B+20B*I
      CALL WRITE(LISTOUT,INIT,NTERM,2)
   20 CONTINUE
      REWIND NFLAG3
      END FILE LISTOUT
      END


      MACHINE READ(1ARG,2ARG,3ARG,4ARG)


* NOTE  G = ADDRESS OF ENTRY TO TYPEWRITER SENSE ROUTINE
*       P = ADDRESS OF PROGRAM CONTROL ROUTINE JUMP  ENTRY
* THIS ROUTINE IS FOR PROGRAM CALL

      LOC(G=31,  P=10)
```

```
* TYPEWRITER MESSAGE CODE TABLE

      CON(T6 =4504041220302204B,  T7 =1120061301050420B,
    *     T8 =1212031200000000B,  T9 =4504041220302204B,
    *     T10=1530121401250420B,  T11=1212031200000000B)
      CON(T12=4504041220302204B,  T13=2006220403260426B,
    *     T14=1411200000000000B,  T15=4504043112140120B,
    *     T40=4504040130152004B,  T41=3406140104060301B,
    *     T42=0414062214163001B,  T43=2022420000000000B)

* TAPE UNIT ASSIGNMENT TABLE
*     ASSIGNMENTS FOR CHANNEL 3/4 LIBRARY TAPE

      CON(K0 =0      ,  K1 =332010B,  K2 =332020B,
    *     K3 =332030B,  K4 =332040B,  K5 =552010B,
    *     K6 =552020B,  K7 =552030B,  K8 =552040B)

* ASSORTED CONSTANTS

      CON(R4 =7373737373737373B,  R16=0070000000000000B)

* TAPE READING ROUTINE

1X    SLJ(N)           SLJ(L+5)         . EXIT/ENTRY
1ARG  ZRO(0)           ZRO(0)           . TAPE UNIT NUMBER ARG.
2ARG  ZRO(0)           ZRO(0)           . INITIAL ADDRESS
3ARG  ZRO(0)           ZRO(0)           . TERMINAL ADDRESS
4ARG  ZRO(0)           ZRO(0)           . MODE, 1 = BINARY, 2 = BCD
      LDA7(1ARG)       INA(-11B)        .
      SIU1(19X)        AJP3(L+3)        . CHECK FOR TU ASSIGNMENT
      ENA(T40)         SLJ4( G)         . GO PRINT ERROR
      SLJ( P)          ZRO(0)           .
      INA(11B)         STA(K0)          .
      LIL1(K0)         LDA1(K0)         .
      ADD7(4ARG)       SAU(4X)          . SET TU CONTROL CODES
      SCL(777B)        SAL(4X)          . INITIALIZE
      SAL(5X)          SAL(11X)         .
      INA(3)           SAU(8X)          .
      INA(2)           SAU(9X)          .
      INA(1)           SAU(11X)         .
      INA(1)           SAU(7X)          .
      LRS(18)          ENA(0)           .
      LLS(3)           SAL(2X)          .
      SAL(3X)          SAU(12X)         .
```

```
        LLS(39)         LDQ(R16)      .
        STA(KO)         LDA(5X)       .
        SSU(KO)         STA(5X)       .
        LDA7(2ARG)      SAU(5X)       .
        LDA(6X)         SSU(KO)       .
        STA(6X)         ENI(0)        .
2X      LDA7(3ARG)      SAL(N)        .
        SAU(6X)         SIL2(19X)     .
3X      ENI2(4)         LIL1(N)       .
4X      EXF(N)          EXF7(N)       . SELECT UNIT
5X      EXF(N)          EXF7(N)       . ACTIVATE CHANNEL
6X      EXF(N)          LDA7(2ARG)    .
        SUB(R4)         LLS(48)       .
        INI1(-1)        LDA1(Z)       .
        INI1(1)         SUB(R4)       .
7X      EXF7(N)         SLJ(15X)      . SENSE ENDFILE
8X      EXF7(N)         SLJ(L+4)      . SENSE PARITY ERROR
9X      EXF7(N)         SLJ(10X)      . SENSE LENGTH ERROR
        QJP1(19X)       AJP(3X)       . SENSE FOR BAD RECORD
        SLJ(19X)        ZRO(0)        . EXIT
        IJP2(L+2)       SLJ(14X)      . SENSE FIVE PARITY ERRORS
10X     IJP2(L+1)       SLJ(13X)      . SENSE FIVE LENGTH ERRORS
        AJP(3X)         QJP(3X)       . SENSE FOR BAD RECORD
11X     EXF(N)          EXF7(N)       . BACKSPACE
12X     LIL1(N)         SLJ(4X)       . RETURN TO REREAD
13X     ENA(T6)         SLJ(17X)      . SET TO INDICATE TROUBLE
14X     ENA(T9)         SLJ(17X)      .
15X     ENA(T12)        SLJ(18X)      .
17X     SLJ4( G)        ZRO(0)        . TROUBLE EXIT
        AJP(19X)        AJP3(3X)      . SENSE ACTION TO TAKE
        SLJ(11X)        ZRO(0)        .
18X     SLJ4( G)        ZRO(0)        . TROUBLE EXIT
        AJP(3X)         AJP3(3X)      . SENSE ACTION TO TAKE
        SLJ(11X)        ZRO(0)        .
19X     ENI1(N)         ENI2(N)       . RE-STORE INDEXES
        SLJ(1X)         ZRO(0)        .
        END

        MACHINE WRITE(1ARG,2ARG,3ARG,4ARG)

* NOTE  G = ADDRESS OF ENTRY TO TYPEWRITER SENSE ROUTINE
*       P = ADDRESS OF PROGRAM CONTROL ROUTINE JUMP  ENTRY
* THIS ROUTINE IS FOR PROGRAM CALL

        RSV(T=2)
        LOC(G=31,  P=10)
```

```
* TYPEWRITER MESSAGE CODE TABLE

     CON(T14=14112000000000B,  T15=45040431121401208,
   *     T16=04112006130105048,  T17=20121203120000008,
   *     T18=45040431121401208,  T19=04153012140125048,
   *     T20=20121203120000008,  T21=45040431121401208,
   *     T22=04200622040326048,  T23=01301520000000B,
   *     T40=45040401301520048,  T41=34061401040603018,
   *     T42=04140622141630018,  T43=2022420000000000B)


* TAPE UNIT ASSIGNMENT TABLE
*    ASSIGNMENTS FOR CHANNEL 3/4 LIBRARY TAPE

     CON(K0 =0      ,  K1 =442010B,  K2 =442020B,
   *    K3 =442030B,  K4 =442040B,  K5 =662010B,
   *    K6 =662020B,  K7 =662030B,  K8 =662040B)


* ASSORTED CONSTANTS

     CON(R4 =7373737373737373B,  R16=0070000000000000B)


* TAPE WRITING ROUTINE

1Y   SLJ(N)       SLJ(L+5)     . EXIT/ENTRY
1ARG ZRO(0)       ZRO(0)       . TAPE UNIT NUMBER ARG.
2ARG ZRO(0)       ZRO(0)       . INITIAL ADDRESS
3ARG ZRO(0)       ZRO(0)       . TERMINAL ADDRESS
4ARG ZRO(0)       ZRO(0)       . MODE, 1 = BINARY, 2 = BCD
     LDA7(1ARG)   INA(-11B)    .
     SIU1(21Y)    AJP3(L+3)    . CHECK FOR TU ASSIGNMENT
     SLJ( P)      ZRO(0)       .
     ENA(T40)     SLJ4( G)     . GO PRINT ERROR
     INA(11B)     STA(K0)      .
     LIL1(K0)     LDA1(K0)     .
     ADD7(4ARG)   SAU(2Y)      . SET TU CONTROL CODES
     SAU(9Y)      SCL(777B)    . INITIALIZE
     SAL(2Y)      SAL(4Y)      .
     SAL(8Y)      SAL(10Y)     .
     INA(3)       SAU(5Y)      .
     SAU(11Y)     INA(2)       .
     SAU(6Y)      SAU(12Y)     .
     INA(1)       SAU(8Y)      .
     SAU(7Y)      SAU(13Y)     .
     LRS(15)      SAL(1YB)     .
     ENI(0)       ENQ(0)       .
```

```
        LLS(39)        LDQ(R16)       .                                    06850
        STA(KO)        LDA(4Y)        .                                    06860
        SSU(KO)        STA(4Y)        . INSERT CHANNEL SELECTION           06870
        LDA(10Y)       SSU(KO)        .                                    06880
        STA(10Y)       SIL2(21Y)      .                                    06890
1YB     LDA7(3ARG)     SAL(N)         .                                    06900
        INA(-1)        SAU(14YB)      .                                    06910
        SAU(15YB)      SAL(20YB)      .                                    06920
        LDA7(2ARG)     SAU(4Y)        .                                    06930
        SAU(10Y)       SAU(14YA)      .                                    06940
        SAL(15YA)      SAL(20YA)      .                                    06950
2Y      EXF(N)         EXF7(N)        . SELECT UNIT                        06960
4Y      EXF(N)         EXF7(N)        . ACTIVATE CHANNEL                   06970
5Y      EXF7(N)        SLJ(17Y)       . SENSE PARITY ERROR                 06980
6Y      EXF7(N)        SLJ(19Y)       . SENSE LENGTH ERROR                 06990
7Y      EXF7(N)        SLJ(21Y)       . SENSE END OF TAPE                  07000
        SLJ(16Y)       ZRO(0)         .                                    07010
8Y      EXF(N)         EXF7(N)        . BACKSPACE                          07020
9Y      EXF(N)         SLJ(13YA)      . SELECT UNIT                        06690
10Y     EXF(N)         EXF7(N)        . WRITE BAD RECORD INDICATION        07040
11Y     EXF7(N)        SLJ(20YA)      . SENSE PARITY ERROR                 07050
12Y     EXF7(N)        SLJ(20YA)      . SENSE LENGTH ERROR                 07060
13Y     EXF7(N)        SLJ(20YA)      . SENSE END OF TAPE                  07070
        SLJ(16Y)       ZRO(0)         .                                    07080
13YA    IJP2(L+1)      SLJ(2Y)        .                                    06790
14YA    LDA(N)         STA(T)         . SET BAD RECORD INDICATION          07090
14YB    LDA(N)         STA(T+1)       .                                    07100
15YA    LDA(R4)        STA(N)         .                                    07110
15YB    STA(N)         SLJ(10Y)       .                                    06780
16Y     ENA(T21)       SLJ4( G)       . TROUBLE EXIT                       07140
        AJP(2Y)        ENI2(0)        . SENSE ACTION TO TAKE               07150
        AJP3(21Y)      SLJ(8Y)        .                                    07160
17Y     ENA(T18)       SLJ4( G)       . TROUBLE EXIT                       07170
18Y     AJP3(21Y)      ENI2(1)        . SENSE ACTION TO TAKE               07180
        AJP(8Y)        ENI2(0)        .                                    07190
        SLJ(8Y)        ZRO(0)         .                                    07200
19Y     ENA(T15)       SLJ4( G)       . TROUBLE EXIT                       07210
        SLJ(18Y)       ZRO(0)         .                                    07220
20YA    LDA(T)         STA(N)         . RESET INIT AND FINAL CELLS         07230
20YB    LDA(N)         STA(N)         .                                    07240
        SLJ(2Y)        ZRO(0)         .                                    07250
21Y     ENI1(N)        ENI2(N)        . RE-STORE INDEXES                   07260
        SLJ(1Y)        ZRO(0)         .                                    07270
        END                                                                07280
        END                                                                07290
```

1

```
* FORTSAT * FORTSAT * FORTSAT * FORTSAT * FORTSAT * FORTSAT * FORTSAT *

*    USNPS FORTRAN SYSTEM RESIDENT PROGRAM  25 SEPT 1962

*         FORTSAT IS A  5K BIAS VERSION OF FORTRAN SIXTY
*         WITH USNPGS SATELLITE SYSTEM IMPLEMENTATION

*         ( CDC VERSION 15 MARCH 1962  - - MODIFIED )
*           LAST UPDATE - - 20 APRIL 1963
*             R.L. HOGG / D. C. GLOVER

*         I/O DESIGNATORS

*              T - KEYBOARD OR TYPEWRITER (01)
*              F - FLEX PAPER TAPE (02)
*              P - BCD PAPER TAPE (INPUT) (03)
*              C - 521 READER (10) PUNCH (12)
*              1 - TU1 CH 3-4 (21)
*              2 - TU2 CH 3-4 (22)
*              3 - TU3 CH 3-4 (23)
*              4 - TU4 CH 3-4 (24)
*              5 - TU5 CH 5-6 (31)
*              6 - TU6 CH 5-6 (32)
*              7 - TU7 CH 5-6 (33)
*              8 - TU8 CH 5-6 (34)
*              9 - TYPEWRITER (01)
*              P - TU4 (OUTPUT) (24)
*              M - MEMORY (06)

*         RESIDENT ROUTINES (NO CALL REQUIRED)

*              CALL -        (TU NO.) (UP TO EIGHT PROGRAM NAMES)
*              CONTROL -     (CONTROL MEDIUM) (CONTROL STATEMENT OUTPUT
*                            MEDIUM) (RUNNING PROGRAM ERROR MEDIUM)
*              REWIND -      (TU NO.)
*              BKSP -        (TU NO.)
*              TIME -        (NO ARGS)  TYPES OUT TIME
*              LIMIT -       (MINUTES) (SECONDS)
*              CLOCK -       (NO ARGS)  STARTS CLOCK
*              EFMARK -      (TU NO.)  THIS IS 17 CODE
*              RUN -         (NO ARGS)  EXECUTES LAST PROGRAM CALLED
*              HOLD -        (NO ARGS) EFFECTIVE FOR NEXT CALL ONLY
```

```
*               CLEAR -      (NO ARGS)  CLEARS MEMORY FROM
*                            RESIDENT BIAS TO CELL 77776
*               SWITCH -     (UP TO EIGHT SETTINGS) NOTE - FIRST THREE
*                            ARE ORDED WITH PHYSICAL SETTING
*                            OF CONSOLE KEYS
*               INPUT -      (MNEMONIC EQPT CODE) (BIOCTAL EQPT CODE)
*               OUTPUT -     (MNEMONIC EQPT CODE) (BIOCTAL EQPT CODE)
*               STOPCK -     (NO ARGS)
*               SET -        (STARTING ADDRESS M-FILE) (RECORD SIZE
*                                                       IN WORDS)
*               SKIP -       (MEDIUM)  (I.D. CODE)
*               LOCK -       (TU NO.)
*               MONITOR -    (INPUT) (OUTPUT) (MODE) (TIME LIMIT)
*                            (ALT OUTPUT) (SOURCE LISTING) (MAP LISTING)
*               SR -         (NO ARGS)  THIS IS A SERVICE ROUTINE CALL
*                            WHICH CALLS THE FOLLOWING  LIB ROUTINES,
*                            COPYS, TRANSFER, VFYLIB, LIST,
*                            TROUBLE, READMT, WRITEMT, LIBFIX

*           BOOTSTRAP FROM CHANNEL 3-4
*           CURRENT LIBRARY LISTING FOLLOWS RESIDENT LISTING



S1    MACHINE RESIDENT


      RSV(T=11, BUF65=9, SATBUF=1)
      LOC(Z=0,J=26,C=60,R=100,W=300,M=531,S=5000)
*     TO CHANGE RESIDENT BIAS, SET S=NEW VALUE


* BCD CODE TABLE

      CON(F0 =12B,F1 =01B,F2 =02B,F3 =03B,F4 =04B,F5 =05B,F6 =06B,
     *    F7 =07B,F10=10B,F11=11B,F12=61B,F13=62B,F14=63B,F15=64B,
     *    F16=65B,F17=66B,F20=67B,F21=70B,F22=71B,F23=41B,F24=42B,
     *    F25=43B,F26=44B,F27=45B,F30=46B,F31=47B,F32=50B,F33=51B,
     *    F34=22B,F35=23B,F36=24B,F37=25B,F40=26B,F41=27B,F42=30B,
     *    F43=31B,F44=73B,F45=53B,F46=34B,F47=13B,F50=54B,F51=21B,
     *    F52=60B,F53=40B,F54=74B,F55=33B,F56=20B,F57=14B        )

* GENERALIZED SUBSTIIUTION TABLE

*         INDEX ON GO, INDEX = CHARACTER BCD CODE
*         UPPER SIX BITS ARE ANALEX PRINTER FIRING ORDER
```

```
*          NEXT 12 BITS ARE CARD IMAGE ALGORITHM CONTROL
*          NEXT 18 BITS ARE NOT USED
*          SEVENTH CHARACTER IS INPUT EQUIP. CONTROL CODE
*          SEVENTH CHARACTER IS OUTPUT EQUIP. CONTROL CODE

       CON(G0 =6100000000000000B,  G1 =0100100000002177B,
      *    G2 =0200200000002222B,  G3 =0300400000002323B,
      *    G4 =0401000000002424B,  G5 =0502000000003131B,
      *    G6 =0604000000003232B,  G7 =0710000000003333B,
      *    G10=1020000000003434B,  G11=1140000000000101B,
      *    G12=0000040000007777B,  G13=4720400000007777B,
      *    G14=4521000000007777B,  G15=6100000000007777B,
      *    G16=6100000000007777B,  G17=6100000000007777B)
       CON(G20=6300000000007777B,  G21=5200140000007777B,
      *    G22=3400240000007777B,  G23=3500440000000101B,
      *    G24=3601040000007777B,  G25=3702040000007777B,
      *    G26=4004040000007777B,  G27=4110040000000000B,
      *    G30=4220040000007777B,  G31=4340040000007777B,
      *    G32=6100000000007777B,  G33=5420440000007777B,
      *    G34=5021040000007777B,  G35=6100000000007777B,
      *    G36=6100000000007777B,  G37=6100000000007777B)
       CON(G40=4500020000007777B,  G41=2300120000007777B,
      *    G42=2400220000007777B,  G43=2500420000007777B,
      *    G44=2601020000000606B,  G45=2702020000007777B,
      *    G46=3004020000007777B,  G47=3110020000000324B,
      *    G50=3220020000007777B,  G51=3340020000007777B,
      *    G52=6100000000007777B,  G53=6220420000007777B,
      *    G54=5321020000007777B,  G55=6100000000007777B,
      *    G56=6100000000007777B,  G57=6100000000007777B)
       CON(G60=4600010000007777B,  G61=1200110000007777B,
      *    G62=1300210000007777B,  G63=1400410000001012B,
      *    G64=1501010000007777B,  G65=1602010000007777B,
      *    G66=1704010000000202B,  G67=2010010000007777B,
      *    G70=2120010000007777B,  G71=2240010000007777B,
      *    G72=6100000000007777B,  G73=4420410000007777B,
      *    G74=5121010000007777B,  G75=6100000000007777B,
      *    G76=6100000000007777B,  G77=6100000000007777B)

* CHARACTER CONVERSION TABLE

*          INDEX = CHARACTER CODE
*          UPPER SIX BITS ARE TYPEWRITER CASE CONTROL
*                77 = UPPER CASE
*                00 = LOWER CASE
*          2ND CHAR. = TYPE OUTPUT CHAR. CONVERSION
*          3RD CHAR. = FLEX CASE CONTROL
*          4TH CHAR. = FLEX OUTPUT CHAR. CONVERSION
*          5TH CHAR. = TYPE UPPER CASE INPUT CONVERSION
```

```
*          6TH CHAR. = TYPE LOWER CASE INPUT CONVERSION
*          7TH CHAR. = FLEX UPPER CASE INPUT CONVERSION
*          8TH CHAR. = FLEX LOWER CASE INPUT CONVERSION

      CON(K0 =7746775620202020B,  K1 =0074007423232323B,
     *    K2 =0070007020132020B,  K3 =0064006446464646B,
     *    K4 =0062006220202020B,  K5 =0066006670707070B,
     *    K6 =0072007245454545B,  K7 =0060006044444444B,
     *    K10=0033003320202020B,  K11=0037003743434343B,
     *    K12=0056005651515151B,  K13=0002774267676767B,
     *    K14=0052005271717171B,  K15=7746775647474747B,
     *    K16=7746775663636363B,  K17=7746775625252525B)
      CON(K20=0004000465656565B,  K21=0044004431313131B,
     *    K22=0024002464646464B,  K23=0001000162626262B,
     *    K24=0034003422222222B,  K25=0017001730303030B,
     *    K26=0031003166666666B,  K27=0027002727272727B,
     *    K30=0025002561616161B,  K31=0021002126262626B,
     *    K32=7746775641414141B,  K33=0040004620101010B,
     *    K34=7737775424242424B,  K35=7746775650505050B,
     *    K36=7746775642424242B,  K37=7746775634111111B)
      CON(K40=0052005233332020B,  K41=0032003220202020B,
     *    K42=0036003673731373B,  K43=0011001120202020B,
     *    K44=0007000720215421B,  K45=0006000620202020B,
     *    K46=0003000320606033B,  K47=0015001520202020B,
     *    K50=0035003520205320B,  K51=0012001220202020B,
     *    K52=7746775620404040B,  K53=7762775020202020B,
     *    K54=7774774420203474B,  K55=7776775620202020B,
     *    K56=7746775674121212B,  K57=7746775620202020B)
      CON(K60=0046774620070707B,  K61=0030003020202020B,
     *    K62=0023002353040404B,  K63=0016001620202020B,
     *    K64=0022002220030303B,  K65=0020002020202020B,
     *    K66=0026002620050505B,  K67=0013001320202020B,
     *    K70=0005000520020202B,  K71=0014001420202020B,
     *    K72=7746775620060606B,  K73=0042004220202020B,
     *    K74=7756005454010101B,  K75=7746775620202020B,
     *    K76=7746775620202020B,  K77=7746775620202020B)

* PROGRAM NAME TABLE

      CON(P0 =4446457123465100B,  P1 =6565654564000000B,
     *    P2 =7145472423000000B,  P3 =4624234724230000B,
     *    P4 =6343466342000000B,  P5 =2223464763420000B,
     *    P6 =6346452351464300B,  P7 =2251000000000000B,
     *    P10=6361434300000000B,  P11=2226712363700000B,
     *    P12=5124450000000000B,  P13=7046436400000000B,
     *    P14=6343656151000000B,  P15=2242714700000000B,
     *    P16=2265230000000000B,  P17=2371446500000000B)
      CON(P20=4371447123000000B,  P21=5165267145640000B,
```

```
*       P22=4346634200000000B,  P23=6566446151420000B,
*       P24=6242224700000000B,  P25=0000000000000000B,
*       P26=0000000000000000B,  P27=0000000000000000B,
*       P30=0000000000000000B,  P31=0000000000000000B,
*       P32=0000000000000000B,  P33=0000000000000000B,
*       P34=0000000000000000B,  P35=0000000000000000B,
*       P36=0000000000000000B,  P37=0000000000000000B)

* BCD MESSAGE CODE TABLE

      CON(E0 =4751466751614420B,  E1 =4546232063614343B,
*          E2 =6564000000000000B,  E3 =2223465161676520B,
*          E4 =4371447123000000B,  E5 =4546232061256171B,
*          E6 =4361624365404040B,  E7 =0000000000000000B,
*          E8 =0000000000000000B,  E9 =2445612222716745B,
*          E10=6564207145472423B,  E11=2044656471244400B,
*          E12=2445612222716745B,  E13=6564204624234724B)
      CON(E14=2320446564712444B,  E15=0000000000000000B,
*          E16=2371446520437144B,  E17=7123000000000000B,
*          E18=2346462044614530B,  E19=2061516724446545B,
*          E20=2322000000000000B,  E21=0000000000000000B,
*          E22=2044714524236522B,  E23=0000000000000000B,
*          E24=2022656346456422B,  E25=0000000000000000B)

* TYPEWRITER MESSAGE CODE TABLE

      CON(T0 =4504041605201636B,  T1 =0424340704201212B,
*          T2 =0312000000000000B,  T3 =4504041630122204B,
*          T4 =1220302204201212B,  T5 =0312000000000000B,
*          T6 =4504041220302204B,  T7 =1120061301050420B,
*          T8 =1212031200000000B,  T9 =4504041220302204B,
*          T10=1530121401250420B,  T11=1212031200000000B)
      CON(T12=4504041220302204B,  T13=2006220403260426B,
*          T14=1411200000000000B,  T15=4504043112140120B,
*          T16=0411200613010504B,  T17=2012120312000000B,
*          T18=4504043112140120B,  T19=0415301214012504B,
*          T20=2012120312000000B,  T21=4504043112140120B,
*          T22=0420062204032604B,  T23=0130152000000000B)

* SERVICE ROUTINES CALLED BY SR

      CON(COPYS=6346473022000000B, TRNSFER=2351614522666551B,
*          VFYLIB=2566304371620000B, LIST=4371222300000000B,
*          TROUBLE=2351462462436500B, READMT=5165616444230000B,
*          WRITEMT=2651712365442300B, LIBFIX=4371626671270000B)
```

```
* 160 CALL ROUTINE CONSTANTS

      CON(IDENT=00000000012311118). RS-022 IDENT
      CON(IDEN2=0000000001231122B). OSAP IDENT
      CON(IDEN3=0000000001231133B). OSAS IDENT
      CON(IDEN4=0000000001231144B). OSAS LOADER, A4.01 IDENT
      CON(IDEN5=0000000001231155B). OSAP LOADER
      CON(E=0, E=0, E=0, E=0)
      CON(SIZE=77B, SIZE2=773B, SIZE3=1214B, SIZE4=77B, SIZE5=23B)
      CON(E=0, E=0, E=0, E=0)
      CON(TAPE1=0000000000332011B)
      CON(BLOCKS=700B). LIMIT ON 160 LIB CALL BLOCK READ BEFORE EXIT

* TAPE CHANNEL ASSIGNMENT TABLE

      CON(U0 =0033200000442000B,  U1 =0055200000662000B)

* ASSORTED CONSTANTS

      CON(R0 =01,R1 =10,R2 =100,R3 =6646512351614540B,
    *     R4 =7373737373737373B,R5 =4500000000000000B,
    *     R6 =2020202020202020B,R7 =7760000000000000B,
    *     R10=6545646671436500B,R11=0000000100000000B,
    *     R12=3777777777777704B,R13=0351244513000000B,
    *     R14=0041254400000000B,R15=6646512362714500B,
    *     R16=0070000000000000B,R17=5165446151420000B)

* DD65 PRINTER SIMULATOR CONSTANTS

      CON(DDSWT=5252525252525252B)
      CON(ND65R=1000B)

*         PSUEDO PRINTER DRUM DESIGNATOR TABLE

      CON(ITAB=3400000006001400B,
    1     LTAB=3400000006241420B,
    2     LTAB=3400000006501440B,
    3     LTAB=3400000006741460B,
    4     LTAB=3400000007201500B,
    5     LTAB=3400000007441520B,
    6     LTAB=3400000007701540B,
    7     LTAB=3400000010141560B)
      CON(JTAB=3400000010401600B,
    1     LTAB=3400000010641620B,
    2     LTAB=3400000011101640B,
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3       LTAB=340000001134166OB,
4       LTAB=3400000011601700B,
5       LTAB=3400000012041720B,
6       LTAB=3400000012301740B,
7       LTAB=3400000012541760B)
  CON(KTAB=3400000013001000B,
1       LTAB=3400000013241020B,
2       LTAB=3400000013501040B,
3       LTAB=3400000013741060B,
4       LTAB=3400000014201100B,
5       LTAB=3400000014441120B,
6       LTAB=3400000014701140B,
7       LTAB=3400000015141160B)
  CON(MTAB=3400000015401200B,
1       LTAB=3400000015641220B,
2       LTAB=3400000016101240B,
3       LTAB=3400000016341260B,
4       LTAB=3400000016601300B,
5       LTAB=3400000017041320B,
6       LTAB=3400000017301340B,
7       LTAB=3400000017541360B)

* INITIAL START/EXITS AND ENTRIES TO RESIDENT ROUTINES

  SLJ(N)            SLJ(L)          .                                  00000
  SLJ(N)            SLJ(1SENS)      . INTERRUPT EXIT/ENTRY             00001
  SLJ(Z+40B)        ZRO(0)          . JUMP TO CONTINUE LOAD            00002
  SLJ(N)            SLJ(3A)         . BCD READ EXIT/ENTRY              00003
  SLJ(N)            SLJ(65DPY)      . BCD WRITE EXIT/ENTRY             00004
  SLJ(N)            SLJ(5A)         . BIN READ EXIT/ENTRY              00005
  SLJ(N)            SLJ(6A)         . BIN WRITE EXIT/ENTRY             00006
  SLJ(N)            SLJ(7A)         . BACKSPACE EXIT/ENTRY             00007
  SLJ(N)            SLJ(8A)         . REWIND EXIT/ENTRY                00010
  SLJ(N)            SLJ(9A)         . ENDFILE EXIT/ENTRY               00011
  EXF(62540B)       SLJ(Z+40B)      . JUMP TO CONTINUE LOAD/RELOAD     00012
  SLJ(N)            SLJ(9M)         . NORMAL RETURN TO MONITOR         00013
  SLJ(N)            SLJ(10A)        . GO TO CHAIN CONNECTOR            00014
  SLJ(N)            SLJ(1E)         . GO INDICATE EQUIPMENT FAILURE    00015
  SLJ(N)            SLJ(2E)         . GO INDICATE PROGRAMMING ERROR    00016
  SLJ(N)            SLJ(11A)        . BCD MESSAGE EXIT/ENTRY           00017
  SLJ(N)            SLJ(N)          . SPARE                            00020
  ZRO(0)            ZRO(0Z)         . ADDR OF PROGRAM START TABLE      00021
  SLJ(2A)           ZRO(0)          . JUMP TO RESUME MONITOR CONTROL   00022
  SLJ(N)            SLJ(5GG)        . TYPE MESSEGE/SENSE FOR ACTION    00023
  SLJ(N)            SLJ(N)          . SPARE                            00024
  SLJ(N)            SLJ(3VV)        . GO LOCK TAPE                     00025
  SLJ(N)            SLJ(N)          . SPARE                            00026
  EXF(32011B)       EXF(32005B)     . REWIND LIBRARY TAPE              00027
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      ENI1(0)            EXF7(32000B)       .                                      00030
      EXF3(Z)            EXF7(32000B)       . REREAD FIRST RESIDENT BLOCK          00031
      ENA(1PCON)         SAU(Z+10B)         . SET JUMP TO PROGRAM CONTROL          00032
      ENA(Z+35B)         SAL(Z+20B)         . SET JUMP TO RELOAD RESIDENT          00033
      ENI2(48)           ENI3(12)           .                                      00034
      ENA(R+54)          STA(Z+3)           .                                      00035
      EXF3(R)            EXF7(32000B)       . READ RESIDENT BLOCK                  00036
      EXF3(R+54)         ENQ(0)             .                                      00037
      EXF7(32003B)       SLJ(Z+35B)         . SENSE PARITY ERROR                   00040
      EXF7(32005B)       SLJ(Z+35B)         . SENSE LENGTH ERROR                   00041
      LDA1(R+6)          STA2(Z)            . TRANSFER WORD TO RESIDENT AREA       00042
      ISK2(T+11)         SLJ(Z+53B)         . SENSE END OF RESIDENT                00043
      EXF(32005B)        SLJ(Z+55B)         .                                      00044
      ISK1(47)           SLJ(Z+50B)         . SENSE END OF BLOCK                   00045
      SLJ(Z+44B)         ZRO(0)             . GO READ NEXT BLOCK                   00046
      STQ3(Z+40B)        IJP3(Z+55B)        . CLEAR SIMULATION LOCATIONS           00047
      STQ(Z+55B)         STQ(Z+56B)         .                                      00050
      STQ(Z)             SLJ(1PCON)         . EXIT TO PROGRAM CONTROL              00051
      ZRO(0)             ZRO(0)             .                                      00052
      ZRO(0)             ZRO(0)             .                                      00053
      ZRO(0)             ZRO(0)             .                                      00054
      ZRO(0)             ZRO(0)             .                                      00055
      ZRO(0)             ZRO(0)             .                                      00056
      ZRO(0)             ZRO(0)             .                                      00057

* CONTROL INFORMATION AND MONITOR TAPE ASSIGNMENT TABLE

      ZRO(0)             ZRO(0)             . END OF FORTRAN MAP FILE              00060
      ZRO(0)             ZRO(0)             . START OF FORTRAN MAP FILE            00061
      ZRO(0)             ZRO(S)             . INITIAL PROGRAM BIAS                 00062
      ZRO(0)             ZRO(S)             . CURRENT PROGRAM BIAS                 00063
      ZRO(0)             ZRO(J)             . INITIAL NUMBER OF PROGRAMS           00064
      ZRO(0)             ZRO(J)             . CURRENT NUMBER OF PROGRAMS           00065
      ZRO(0)             ZRO1(PO)           . ADDRESS OF PROGRAM-NAME TABLE        00066
      ZRO(0)             ZRO1(PZ)           . ADDRESS OF PROGRAM-START TABLE       00067
      ZRO(0)             ZRO(1)             . MONITOR TAPE-ASSIGNMENT TABLE        00070
      ZRO(0)             ZRO(2)             .                                      00071
      ZRO(0)             ZRO(3)             .                                      00072
      ZRO(0)             ZRO(4)             .                                      00073
      ZRO(0)             ZRO(5)             .                                      00074
      ZRO(0)             ZRO(6)             .                                      00075
      ZRO(0)             ZRO(7)             .                                      00076
      ZRO(0)             ZRO(8)             .                                      00077

* READ BUFFER

      ZRO(0)             ZRO(0)             . READ BUFFER                          00100
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ZRO(0)     ZRO(0)     .                         00101
ZRO(0)     ZRO(0)     .                         00102
ZRO(0)     ZRO(0)     .                         00103
ZRO(0)     ZRO(0)     .                         00104
ZRO(0)     ZRO(0)     .                         00105
ZRO(0)     ZRO(0)     .                         00106
ZRO(0)     ZRO(0)     .                         00107
ZRO(0)     ZRO(0)     .                         00110
ZRO(0)     ZRO(0)     .                         00111
ZRO(0)     ZRO(0)     .                         00112
ZRO(0)     ZRO(0)     .                         00113
ZRO(0)     ZRO(0)     .                         00114
ZRO(0)     ZRO(0)     .                         00115
ZRO(0)     ZRO(0)     .                         00116
ZRO(0)     ZRO(0)     .                         00117
ZRO(0)     ZRO(0)     .                         00120
ZRO(0)     ZRO(0)     .                         00121
ZRO(0)     ZRO(0)     .                         00122
ZRO(0)     ZRO(0)     .                         00123
ZRO(0)     ZRO(0)     .                         00124
ZRO(0)     ZRO(0)     .                         00125
ZRO(0)     ZRO(0)     .                         00126
ZRO(0)     ZRO(0)     .                         00127
ZRO(0)     ZRO(0)     .                         00130
ZRO(0)     ZRO(0)     .                         00131
ZRO(0)     ZRO(0)     .                         00132
ZRO(0)     ZRO(0)     .                         00133
ZRO(0)     ZRO(0)     .                         00134
ZRO(0)     ZRO(0)     .                         00135
ZRO(0)     ZRO(0)     .                         00136
ZRO(0)     ZRO(0)     .                         00137
ZRO(0)     ZRO(0)     .                         00140
ZRO(0)     ZRO(0)     .                         00141
ZRO(0)     ZRO(0)     .                         00142
ZRO(0)     ZRO(0)     .                         00143
ZRO(0)     ZRO(0)     .                         00144
ZRO(0)     ZRO(0)     .                         00145
ZRO(0)     ZRO(0)     .                         00146
ZRO(0)     ZRO(0)     .                         00147
ZRO(0)     ZRO(0)     .                         00150
ZRO(0)     ZRO(0)     .                         00151
ZRO(0)     ZRO(0)     .                         00152
ZRO(0)     ZRO(0)     .                         00153
ZRO(0)     ZRO(0)     .                         00154
ZRO(0)     ZRO(0)     .                         00155
ZRO(0)     ZRO(0)     .                         00156
ZRO(0)     ZRO(0)     .                         00157
ZRO(0)     ZRO(0)     .                         00160
ZRO(0)     ZRO(0)     .                         00161
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ZRO(0)     ZRO(0)     .
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ZRO(0)     ZRO(0)     .
ZRO(0)     ZRO(0)     .
ZRO(0)     ZRO(0)     .
ZRO(0)     ZRO(0)     .
ZRO(0)     ZRO(0)     .
ZRO(0)     ZRO(0)     .
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        ZRO(0)        ZRO(0)        .                         00243
        ZRO(0)        ZRO(0)        .                         00244
        ZRO(0)        ZRO(0)        .                         00245
        ZRO(0)        ZRO(0)        .                         00246
        ZRO(0)        ZRO(0)        .                         00247
        ZRO(0)        ZRO(0)        .                         00250
        ZRO(0)        ZRO(0)        .                         00251
        ZRO(0)        ZRO(0)        .                         00252
        ZRO(0)        ZRO(0)        .                         00253
        ZRO(0)        ZRO(0)        .                         00254
        ZRO(0)        ZRO(0)        .                         00255
        ZRO(0)        ZRO(0)        .                         00256
        ZRO(0)        ZRO(0)        .                         00257
        ZRO(0)        ZRO(0)        .                         00260
        ZRO(0)        ZRO(0)        .                         00261
        ZRO(0)        ZRO(0)        .                         00262
        ZRO(0)        ZRO(0)        .                         00263
        ZRO(0)        ZRO(0)        .                         00264
        ZRO(0)        ZRO(0)        .                         00265
        ZRO(0)        ZRO(0)        .                         00266
        ZRO(0)        ZRO(0)        .                         00267
        ZRO(0)        ZRO(0)        .                         00270
        ZRO(0)        ZRO(0)        .                         00271
        ZRO(0)        ZRO(0)        .                         00272
        ZRO(0)        ZRO(0)        .                         00273
        ZRO(0)        ZRO(0)        .                         00274
        ZRO(0)        ZRO(0)        .                         00275
        ZRO(0)        ZRO(0)        .                         00276
        ZRO(0)        ZRO(0)        .                         00277

* WRITE BUFFER

        ZRO(0)        ZRO(0)        . WRITE BUFFER            00300
        ZRO(0)        ZRO(0)        .                         00301
        ZRO(0)        ZRO(0)        .                         00302
        ZRO(0)        ZRO(0)        .                         00303
        ZRO(0)        ZRO(0)        .                         00304
        ZRO(0)        ZRO(0)        .                         00305
        ZRO(0)        ZRO(0)        .                         00306
        ZRO(0)        ZRO(0)        .                         00307
        ZRO(0)        ZRO(0)        .                         00310
        ZRO(0)        ZRO(0)        .                         00311
        ZRO(0)        ZRO(0)        .                         00312
        ZRO(0)        ZRO(0)        .                         00313
        ZRO(0)        ZRO(0)        .                         00314
        ZRO(0)        ZRO(0)        .                         00315
        ZRO(0)        ZRO(0)        .                         00316
        ZRO(0)        ZRO(0)        .                         00317
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ZRO(0)     ZRO(0)     .     00320
ZRO(0)     ZRO(0)     .     00321
ZRO(0)     ZRO(0)     .     00322
ZRO(0)     ZRO(0)     .     00323
ZRO(0)     ZRO(0)     .     00324
ZRO(0)     ZRO(0)     .     00325
ZRO(0)     ZRO(0)     .     00326
ZRO(0)     ZRO(0)     .     00327
ZRO(0)     ZRO(0)     .     00330
ZRO(0)     ZRO(0)     .     00331
ZRO(0)     ZRO(0)     .     00332
ZRO(0)     ZRO(0)     .     00333
ZRO(0)     ZRO(0)     .     00334
ZRO(0)     ZRO(0)     .     00335
ZRO(0)     ZRO(0)     .     00336
ZRO(0)     ZRO(0)     .     00337
ZRO(0)     ZRO(0)     .     00340
ZRO(0)     ZRO(0)     .     00341
ZRO(0)     ZRO(0)     .     00342
ZRO(0)     ZRO(0)     .     00343
ZRO(0)     ZRO(0)     .     00344
ZRO(0)     ZRO(0)     .     00345
ZRO(0)     ZRO(0)     .     00346
ZRO(0)     ZRO(0)     .     00347
ZRO(0)     ZRO(0)     .     00350
ZRO(0)     ZRO(0)     .     00351
ZRO(0)     ZRO(0)     .     00352
ZRO(0)     ZRO(0)     .     00353
ZRO(0)     ZRO(0)     .     00354
ZRO(0)     ZRO(0)     .     00355
ZRO(0)     ZRO(0)     .     00356
ZRO(0)     ZRO(0)     .     00357
ZRO(0)     ZRO(0)     .     00360
ZRO(0)     ZRO(0)     .     00361
ZRO(0)     ZRO(0)     .     00362
ZRO(0)     ZRO(0)     .     00363
ZRO(0)     ZRO(0)     .     00364
ZRO(0)     ZRO(0)     .     00365
ZRO(0)     ZRO(0)     .     00366
ZRO(0)     ZRO(0)     .     00367
ZRO(0)     ZRO(0)     .     00370
ZRO(0)     ZRO(0)     .     00371
ZRO(0)     ZRO(0)     .     00372
ZRO(0)     ZRO(0)     .     00373
ZRO(0)     ZRO(0)     .     00374
ZRO(0)     ZRO(0)     .     00375
ZRO(0)     ZRO(0)     .     00376
ZRO(0)     ZRO(0)     .     00377
ZRO(0)     ZRO(0)     .     00400
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ZRO(0)      ZRO(0)      .                           00402
ZRO(0)      ZRO(0)      .                           00403
ZRO(0)      ZRO(0)      .                           00404
ZRO(0)      ZRO(0)      .                           00405
ZRO(0)      ZRO(0)      .                           00406
ZRO(0)      ZRO(0)      .                           00407
ZRO(0)      ZRO(0)      .                           00410
ZRO(0)      ZRO(0)      .                           00411
ZRO(0)      ZRO(0)      .                           00412
ZRO(0)      ZRO(0)      .                           00413
ZRO(0)      ZRO(0)      .                           00414
ZRO(0)      ZRO(0)      .                           00415
ZRO(0)      ZRO(0)      .                           00416
ZRO(0)      ZRO(0)      .                           00417
ZRO(0)      ZRO(0)      .                           00420
ZRO(0)      ZRO(0)      .                           00421
ZRO(0)      ZRO(0)      .                           00422
ZRO(0)      ZRO(0)      .                           00423
ZRO(0)      ZRO(0)      .                           00424
ZRO(0)      ZRO(0)      .                           00425
ZRO(0)      ZRO(0)      .                           00426
ZRO(0)      ZRO(0)      .                           00427
ZRO(0)      ZRO(0)      .                           00430
ZRO(0)      ZRO(0)      .                           00431
ZRO(0)      ZRO(0)      .                           00432
ZRO(0)      ZRO(0)      .                           00433
ZRO(0)      ZRO(0)      .                           00434
ZRO(0)      ZRO(0)      .                           00435
ZRO(0)      ZRO(0)      .                           00436
ZRO(0)      ZRO(0)      .                           00437
ZRO(0)      ZRO(0)      .                           00440
ZRO(0)      ZRO(0)      .                           00441
ZRO(0)      ZRO(0)      .                           00442
ZRO(0)      ZRO(0)      .                           00443
ZRO(0)      ZRO(0)      .                           00444
ZRO(0)      ZRO(0)      .                           00445
ZRO(0)      ZRO(0)      .                           00446
ZRO(0)      ZRO(0)      .                           00447
ZRO(0)      ZRO(0)      .                           00450
ZRO(0)      ZRO(0)      .                           00451
ZRO(0)      ZRO(0)      .                           00452
ZRO(0)      ZRO(0)      .                           00453
ZRO(0)      ZRO(0)      .                           00454
ZRO(0)      ZRO(0)      .                           00455
ZRO(0)      ZRO(0)      .                           00456
ZRO(0)      ZRO(0)      .                           00457
ZRO(0)      ZRO(0)      .                           00460
ZRO(0)      ZRO(0)      .                           00461
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        ZRO(0)            ZRO(0)            .
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        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
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        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
* LISTABLE OUTPUT BUFFER
        ZRO(0)            ZRO(0)            . MONITOR OUTPUT BUFFER
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
        ZRO(0)            ZRO(0)            .
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         ZRO(0)            ZRO(0)            .                          00540
         ZRO(0)            ZRO(0)            .                          00541
         ZRO(0)            ZRO(0)            .                          00542
         ZRO(0)            ZRO(0)            .                          00543
         ZRO(0)            ZRO(0)            .                          00544
         ZRO(0)            ZRO(0)            .                          00545
         ZRO(0)            ZRO(0)            .                          00546
         ZRO(0)            ZRO(0)            .                          00547

* PUNCHED CARD BUFFER

         ZRO(0)            ZRO(0)            . MONITOR PUNCH BUFFER     00550
         ZRO(0)            ZRO(0)            .                          00551
         ZRO(0)            ZRO(0)            .                          00552
         ZRO(0)            ZRO(0)            .                          00553
         ZRO(0)            ZRO(0)            .                          00554
         ZRO(0)            ZRO(0)            .                          00555
         ZRO(0)            ZRO(0)            .                          00556
         ZRO(0)            ZRO(0)            .                          00557
         ZRO(0)            ZRO(0)            .                          00560
         ZRO(0)            ZRO(0)            .                          00561
         ZRO(0)            ZRO(0)            .                          00562
         ZRO(0)            ZRO(0)            .                          00563
         ZRO(0)            ZRO(0)            .                          00564
         ZRO(0)            ZRO(0)            .                          00565
         ZRO(0)            ZRO(0)            .                          00566
         ZRO(0)            ZRO(0)            .                          00567
         ZRO(0)            ZRO(0)            .                          00570
         ZRO(0)            ZRO(0)            .                          00571
         ZRO(0)            ZRO(0)            .                          00572
         ZRO(0)            ZRO(0)            .                          00573
         ZRO(0)            ZRO(0)            .                          00574
         ZRO(0)            ZRO(0)            .                          00575
         ZRO(0)            ZRO(0)            .                          00576
         ZRO(0)            ZRO(0)            .                          00577

* STACKED JOB BUFFER

         ZRO(0)            ZRO(0)            . MONITOR INPUT BUFFER     00600
         ZRO(0)            ZRO(0)            .                          00601
         ZRO(0)            ZRO(0)            .                          00602
         ZRO(0)            ZRO(0)            .                          00603
         ZRO(0)            ZRO(0)            .                          00604
         ZRO(0)            ZRO(0)            .                          00605
         ZRO(0)            ZRO(0)            .                          00606
         ZRO(0)            ZRO(0)            .                          00607
         ZRO(0)            ZRO(0)            .                          00610
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         ZRO(0)          ZRO(0)          .                                        00611
         ZRO(0)          ZRO(0)          .                                        00612
         ZRO(0)          ZRO(0)          .                                        00613
         ZRO(0)          ZRO(0)          .                                        00614
         ZRO(0)          ZRO(0)          .                                        00615
         ZRO(0)          ZRO(0)          .                                        00616
         ZRO(0)          ZRO(0)          .                                        00617
         ZRO(0)          ZRO(0)          .                                        00620
         ZRO(0)          ZRO(0)          .                                        00621
         ZRO(0)          ZRO(0)          .                                        00622
         ZRO(0)          ZRO(0)          .                                        00623
         ZRO(0)          ZRO(0)          .                                        00624
         ZRO(0)          ZRO(0)          .                                        00625
         ZRO(0)          ZRO(0)          .                                        00626
         ZRO(0)          ZRO(0)          .                                        00627

* PROGRAM START TABLE

OZ       ZRO(7)          ZRO(1M)         . MONITOR                                00630
         ZRO(7)          ZRO(1M)         . EEEND                                  00631
         ZRO(2)          ZRO(1S)         . INPUT                                  00632
         ZRO(2)          ZRO(2S)         . OUTPUT                                 00633
         ZRO(0)          ZRO(1T)         . CLOCK                                  00634
         ZRO(0)          ZRO(2T)         . STOPCK                                 00635
         ZRO(3)          ZRO(1K)         . CONTROL                                00636
         ZRO(0)          ZRO(1SR)        . SR                                     00637
         ZRO(9)          ZRO(1C)         . CALL                                   00640
         ZRO(6)          ZRO(1J)         . SWITCH                                 00641
         ZRO(0)          ZRO(1Q)         . RUN                                    00642
         ZRO(0)          ZRO(2Q)         . HOLD                                   00643
         ZRO(0)          ZRO(3Q)         . CLEAR                                  00644
         ZRO(2)          ZRO(4Q)         . SKIP                                   00645
         ZRO(2)          ZRO(3S)         . SET                                    00646
         ZRO(0)          ZRO(3T)         . TIME                                   00647
         ZRO(2)          ZRO(4T)         . LIMIT                                  00650
         ZRO(1)          ZRO(1V)         . REWIND                                 00651
         ZRO(1)          ZRO(3V)         . LOCK                                   00652
         ZRO(1)          ZRO(5V)         . EFMARK                                 00653
         ZRO(1)          ZRO(7V)         . BKSP                                   00654
         ZRO(0)          ZRO(00)         . SPARE                                  00655
         ZRO(0)          ZRO(0)          . TRANSIENT PROGRAM STARTS               00656
         ZRO(0)          ZRO(0)          .                                        00657
         ZRO(0)          ZRO(0)          .                                        00660
         ZRO(0)          ZRO(0)          .                                        00661
         ZRO(0)          ZRO(0)          .                                        00662
         ZRO(0)          ZRO(0)          .                                        00663
         ZRO(0)          ZRO(0)          .                                        00664
         ZRO(0)          ZRO(0)          .                                        00665
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        ZRO(0)          ZRO(0)            .                                  00666
        ZRO(0)          ZRO(0)            .                                  00667
        ZRO(0)          ZRO(0)            . PAD                              00670
        ZRO(0)          ZRO(G47)          . PRINT MEDIUM DESIGNATOR CELL     00671
0SWT    SEV7(77777B)    SEV7(77777B)      . SATELLITE MONITOR JOB SWITCH     00672
1SWT    SEV7(77777B)    SEV7(77777B)      . 160 LIBRARY CALL LOCK-OUT        00673
1ERSW   ZRO(0)          ZRO(0)            .                                  00674
1TRIG   SLJ(N)          STA(0SWT)         . TRIGGER ROUTINE                  00675
        SLJ(L-1)        ZRO(0)            .     FOR SATELLITE MONITOR        00676
1CALL   SLJ(N)          SLJ(160CL)        . 160 SAT LIBRARY CALL ENTRY       00677
1PCON   EXF(62500B)     SLJ1(L+6)         . RELEASE DIRECT / TEST NO DD65    00700
        EXF(52502B)     EXF(62502B)       . TAKE READ/WRITE CONTROL          00701
        EXF(77010B)     ISK1(1000B)       . SEL. DD65                        00702
        EXF7(77010B)    SLJ(1P)           . SENSE DD65 AVAILABLE             00703
        ENI(0)          OUT(Z+40B)        . CLEAR DD65 CORE                  00704
        ISK1(1000B)     SLJ(L-1)          . LOOP UNTIL CLEAR                 00705
        EXF(62560B)     SLJ(1P)           . GO TO PROGRAM CONTROL            00706

* TIME ADVANCE ROUTINE

1A      EXF(70B)        STA(T+8)          . CLEAR FAULT                      00707
        SSK(Z)          SLJ(Z+7)          . SENSE ONE-SECOND OVERFLOW        00710
        LDA(R12)        STA(Z)            . RESET ONE-SECOND COUNT           00711
        RAO(Z+50B)      SUB(Z+57B)        . INCREMENT TIME AT 50             00712
        AJP2(L+2)       LDA(T+8)          . SENSE LIMIT AT 57                00713
        SLJ(Z+7)        ZRO(0)            . EXIT THROUGH 7                   00714
2A      EXF(2000B)      ENA(L+3)          . STOP CLOCK                       00715
        SAU(Z+7)        LDA(R11)          . SET TO ISSUE LIMIT INDICATION    00716
        STA(Z+57B)      SLJ(Z+7)          . EXIT THROUGH 7                   00717
        ENA(1)          SAL(2V)           . REWIND LIBRARY TAPE              00720
        SLJ4(1V)        ZRO(0)            .                                  00721
        ENA(E16)        ENI(0)            . SET TO INDICATE LIMIT            00722
        SSK(2M)         SLJ(2E)           . SENSE NO MONITOR CONTROL         00723
        SLJ4(6G)        ZRO(0)            . TYPE LIMIT INDICATION            00724
        EXF(1000B)      SLJ(9M)           . RETURN TO MONITOR                00725

* BCD READ SWITCH

3A      SSK(3M)         SLJ(L+6)          . SENSE FULL MONITOR CONTROL       00726
        SSK(2M)         SLJ(L+3)          . SENSE PARTIAL MONITOR CONTROL    00727
        SLJ4(1R)        ZRO(0)            . GO READ BCD RECORD               00730
        SLJ(3AEX)       ZRO(0)            .                                  00731
        EQS(63B)        SLJ(L-2)          . SENSE CARD REQUEST               00732
        LDA(2M)         SLJ(L-3)          . SET TO READ CARD IMAGE           00733
        LDA(2M)         ENI2(0)           .                                  00734
        THS(9)          SLJ(L+19)         . SENSE STACKED-JOB TAPE           00735
        THS(5)          SLJ(L+2)          . SENSE FIRST OR SECOND BANK       00736
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       INA(3200B)      SLJ(L+2)        .                                  00737
       INA(5174B)      ENI2(1)         .                                  00740
       ALS(3)          INA(2)          .                                  00741
       SAU(L+9)        SAU(L+11)       . SET TO SELECT TAPE UNIT          00742
       LDQ(R6)         EXF7(31B)       . SENSE CHANNELS INACTIVE          00743
       ENI1(9)         EXF7(51B)       .                                  00744
       LDA1(M+39)      STA1(R)         . TRANSFER FROM BUFFER             00745
       IJP1(L-1)       ENI1(4)         .                                  00746
       STQ1(R+10)      IJP1(L)         .                                  00747
       EXF(62540B)     SLJ4(3G)        . DISASSEMBLE READ BUFFER          00750
       ENQ(M+49)       STQ(Z+3)        .                                  00751
       STQ(Z+5)        IJP2(L+3)       .                                  00752
       EXF(N)          EXF7(32000B)    . READ NEXT BLOCK TO BUFFER        00753
       EXF3(M+39)      SLJ(3AEX)       .                                  00754
       EXF(N)          EXF7(52000B)    .                                  00755
       EXF5(M+39)      EXF7(52000B)    .                                  00756
       ENI(0)          SLJ(3AEX)       .                                  00757
       EQS(63B)        SLJ(L-24)       . SENSE STACKED-JOB DECK           00760
       ENI1(23)        EXF7(11B)       . SENSE CHANNEL INACTIVE           00761
       LDA1(M+39)      STA1(R+80)      . TRANSFER FROM BUFFER             00762
       IJP1(L-1)       SLJ4(3R)        . GO PROCESS CARD IMAGE            00763
       EXF(62540B)     ENI1(79)        .                                  00764
       LDA1(R)         INA(-14B)       .                                  00765
       AJP1(L+2)       ENA(40B)        . SENSE ALTERNATE DASH             00766
       STA1(R)         ENI(0)          .                                  00767
       IJP1(L-3)       ENI(0)          .                                  00770
       ENQ(M+63)       STQ(Z+1)        .                                  00771
       ENA(14001B)     ADD(T+11)       .                                  00772
       SAU(L+1)        EXF7(24004B)    .                                  00773
       EXF(N)          EXF1(M+39)      . READ NEXT CARD TO BUFFER         00774
       ENI(0)          EXF7(24004B)    .                                  00775
3AEX   EXF(62560B)     ENA(+0)         . RELEASE COMM FLAG 1              00776
       STA(1ERSW)      SLJ(Z+11B)      . CLEAR ERROR FLAG / EXIT VIA 7    00777

* BCD WRITE SWITCH

4A     SSK(3M)         SLJ(L+11)       . SENSE FULL MONITOR CONTROL       01000
       SSK(2M)         SLJ(L+7)        . SENSE PARTIAL MONITOR CONTROL    01001
       EQS(63B)        SLJ(L+4)        . SENSE CARD REQUEST               01002
       LDQ(G63)        LDL(77B)        .                                  01003
       INA(-12B)       AJP(L+12)       . SENSE CARD-PUNCH REASSIGNMENT    01004
       ENA(63B)        ENI(0)          .                                  01005
       SLJ4(1W)        ZRO(0)          . GO WRITE BCD RECORD              01006
       SLJ(4AEX)       ZRO(0)          .                                  01007
       EQS(2M)         SLJ(L-2)        . SENSE STACKED-JOB MEDIUM         01010
       THS(9)          SLJ(L-3)        .                                  01011
       ENA(27B)        SLJ(L-4)        .                                  01012
       EQS(63B)        SLJ(L+13)       . SENSE CARD REQUEST               01013
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        LDA(6M)          AJP(L+12)      . SENSE PUNCH-CARD MEDIUM          01014
        INA(-63B)        AJP(L+3)       . SENSE ON-LINE PUNCHING           01015
        ENA(0)           SLJ4(8G)       . SENSE ALL CHANNELS INACTIVE      01016
        LDA(6M)          SLJ(L-9)       .                                  01017
        SLJ4(3W)         ZRO(0)         . GO FORM CARD IMAGE               01020
        ENI1(23)         EXF7(21B)      . SENSE CHANNEL INACTIVE           01021
        LDA1(W)          STA1(M+15)     . TRANSFER TO BUFFER               01022
        IJP1(L-1)        SLJ4(1FLAG)    .                                  01023
        ENA(M+39)        EXF7(14004B)   .                                  01024
        EXF(24004B)      SAL(Z+2)       .                                  01025
        EXF2(M+15)       EXF7(14004B)   . PUNCH NEXT CARD FROM BUFFER      01026
        ENI(0)           SLJ(4AEX)      .                                  01027
        LDA(3M)          ENI2(0)        .                                  01030
        THS(9)           SLJ(L-19)      . SENSE LISTABLE-OUTPUT TAPE       01031
        THS(5)           SLJ(L+2)       . SENSE FIRST OR SECOND BANK       01032
        INA(4200B)       SLJ(L+2)       .                                  01033
        INA(6174B)       ENI2(1)        .                                  01034
        ALS(3)           INA(2)         .                                  01035
        SAU(L+7)         SAU(L+9)       . SET TO SELECT TAPE UNIT          01036
        EXF(62540B)      SLJ4(4G)       . ASSEMBLE WRITE BUFFER            01037
        ENI1(14)         EXF7(41B)      . SENSE CHANNELS INACTIVE          01040
        ENQ(M+15)        EXF7(51B)      .                                  01041
        LDA1(W)          STA1(M)        . TRANSFER TO BUFFER               01042
        IJP1(L-1)        STQ(Z+4)       .                                  01043
        STQ(Z+6)         IJP2(L+3)      .                                  01044
        EXF(N)           EXF7(42000B)   . WRITE NEXT BLOCK FROM BUFFER     01045
        EXF4(M)          SLJ(4AEX)      .                                  01046
        EXF(N)           EXF7(62000B)   .                                  01047
        EXF6(M)          EXF7(62000B)   .                                  01050
4AEX    EXF(62560B)      ENI(0)         .                                  01051
        SSK(0SWT)        SLJ(L+2)       . ERRORS TO SATELLITE ROUTINE      01052
        SLJ(Z+12B)       ZRO(0)         .                                  01053
        SSK(1ERSW)       SLJ(Z+12B)     .                                  01054
        LDA(3M)          INA(-56B)      .                                  01055
        AJP(Z+12B)       ENA(Z+12B)     .                                  01056
        SAU(1W)          SLJ(7W)        .                                  01057

* BIN READ SWITCH

5A      SSK(2M)          SLJ4(12A)      . SENSE NO MONITOR CONTROL         01060
        SLJ4(1I)         ZRO(0)         . GO READ BINARY RECORD            01061
        SLJ(Z+13B)       ZRO(0)         . EXIT THROUGH 13                  01062

* BIN WRITE SWITCH

6A      SSK(2M)          SLJ4(3G)       . SENSE NO MONITOR CONTROL         01063
        SLJ4(1O)         ZRO(0)         . GO WRITE BINARY RECORD           01064
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      SLJ(Z+14B)       ZRO(0)            . EXIT THROUGH 14                  01065

* BACKSPACE SWITCH

7A    SSK(2M)          SLJ4(12A)         . SENSE NO MONITOR CONTROL         01066
      SAL(8V)          SLJ4(7V)          . BACKSPACE                        01067
      SLJ(Z+15B)       ZRO(0)            . EXIT THROUGH 15                  01070

* REWIND SWITCH

8A    SSK(2M)          SLJ4(8G)          . SENSE NO MONITOR CONTROL         01071
      SAL(2V)          SLJ4(1V)          . REWIND                           01072
      SLJ(Z+16B)       ZRO(0)            . EXIT THROUGH 16                  01073

* ENDFILE SWITCH

9A    SSK(2M)          SLJ4(12A)         . SENSE NO MONITOR CONTROL         01074
      SAL(6V)          SLJ4(5V)          . ENDFILE                          01075
      SLJ(Z+17B)       ZRO(0)            . EXIT THROUGH 17                  01076

* CHAIN CONNECTOR

10A   SAL(L+1)         INA(1)            . SET TO PICK ARGUMENTS            01077
      SAL(L+1)         LDA7(N)           . TRANSFER ARGUMENTS               01100
      STA(3C)          LDA7(N)           .                                  01101
      STA(2C)          SLJ4(1C)          . CALL NEXT LINK                   01102
      SLJ(1Q)          ZRO(0)            . GO EXECUTE ASSEMBLED PROGRAM     01103

* BCD MESSAGE SWITCH

11A   SSK(2M)          SLJ(L+3)          . SENSE NO MONITOR CONTROL         01104
      SLJ4(6G)         ZRO(0)            . GO OUTPUT BCD MESSAGE            01105
      SLJ(Z+25B)       ZRO(0)            . EXIT THROUGH 25                  01106
      SAU(L+1)         SAL(L+2)          .                                  01107
      LDA(N)           SCM(R3)           .                                  01110
      AJP(Z+25B)       ENA(N)            . SENSE FORTRAN-E                  01111
      SLJ(2E)          ZRO(0)            . EXIT TO STACK MESSAGE            01112

* TAPE ASSIGNMENT CHECK ROUTINE

12A   SLJ(N)           ENI1(3)           .                                  01113
      EQS(1)           SLJ(L+2)          . SENSE LIBRARY TAPE               01114
      SLJ(12A)         ZRO(0)            .                                  01115
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        ALS(24)          LQC(77777B)      .                                     01116
        MEQ1(C+8)        SLJ(L+3)         .                                     01117
        ALS(24)          SLJ4(8G)         .                                     01120
        SLJ(L-6)         ZRO(0)           .                                     01121
        LIU1(L-7)        INI1(1B)         .                                     01122
        SIU1(L-8)        SLJ(L-8)         .                                     01123

* CALL ROUTINE

1C      SLJ(N)           SLJ(L+10)        . EXIT/ENTRY                          01124
2C      ZRO(0)           ZRO(0)           . LIBRARY MEDIUM                      01125
3C      ZRO(0)           ZRO(0)           . PROGRAM-NAME LIST                   01126
        ZRO(0)           ZRO(0)           .                                     01127
        ZRO(0)           ZRO(0)           .                                     01130
        ZRO(0)           ZRO(0)           .                                     01131
        ZRO(0)           ZRO(0)           .                                     01132
        ZRO(0)           ZRO(0)           .                                     01133
        ZRO(0)           ZRO(0)           .                                     01134
        ZRO(0)           ZRO(0)           .                                     01135
        LDQ(4M)          QJP1(L+3)        . SENSE MONITOR CONTROL               01136
        LDA(2C)          SAL(2V)          . REWIND LIBRARY MEDIUM               01137
        SLJ4(1V)         ZRO(0)           .                                     01140
        LDA(C+4)         STA(C+5)         . CLEAR TRANSIENT PROGRAMS            01141
        LDA(C+2)         STA(C+3)         . RESET PROGRAM BIAS                  01142
        ENI1(7)          ENI5(1)          .                                     01143
        LDA1(3C)         ENQ(0)           . POSITION NAMES                      01144
        LRS(6)           AJP1(_)          .                                     01145
        STQ1(3C)         IJP1(L-2)        . LOOP                                01146
4C      LDA(2C)          SLJ4(1I)         . READ BINARY BLOCK                   01147
5C      LDA(R)           AJP(L-1)         .                                     01150
        LDQ(3C)          ENI(0)           .                                     01151
        IJP5(L+1)        SLJ(L+2)         .                                     01152
        QJP1(L+1)        STA(3C)          . SENSE NO PROGRAM-NAME LIST          01153
        SCM(R10)         AJP(9C)          . SENSE END OF LIBRARY                01154
        LDA(R)           ENI1(3)          .                                     01155
        EQS1(3C)         SLJ(4C)          . LOOP TO CALLED NAME                 01156
        LIL3(C+5)        STA3(P0)         . STORE PROGRAM NAME                  01157
        LDQ(R+1)         LDL(77777B)      . PROCESS PARAMETERS                  01160
        STA(T)           QRS(24)          .                                     01161
        LDL(77777B)      ADD(T)           .                                     01162
        ADD(C+3)         SUB(77777B)      .                                     01163
        AJP2(8C)         LDQ(R+1)         . SENSE OVERFLOW OF MEMORY            01164
        QLS(9)           ENI(0)           .                                     01165
        LDL(777B)        ALS(24)          .                                     01166
        ADD(C+3)         STA3(0Z)         .                                     01167
        QLS(15)          LDL(77777B)      .                                     01170
        ADD(C+3)         STA(T+7)         .                                     01171
        LDA(C+3)         STA(T+3)         .                                     01172
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         ENA(0)          STA1(3C)        . CLEAR NAME FROM LIST                  01173
         RAD(C+5)        ENI4(0)         .                                       01174
6C       ENI1(0)         ENI(0)          .                                       01175
         LDA1(R+6)       STA7(T+3)       . COPY WORD                             01176
         SSH(R+2)        SLJ(L+3)        . SENSE UPPER RELATIVE ADDRESS          01177
         LDA(C+3)        ALS(24)         .                                       01200
         RAD7(T+3)       ENI(0)          . MODIFY UPPER ADDRESS                  01201
         SSH(R+4)        SLJ(L+2)        . SENSE LOWER RELATIVE ADDRESS          01202
         LDA(C+3)        RAD7(T+3)       . MODIFY LOWER ADDRESS                  01203
         RAD(T+3)        ENI(0)          . ADVANCE PROGRAM ADDRESS               01204
         ISK1(47)        SLJ(L-7)        . LOOP                                  01205
         LDA(2C)         SLJ4(1I)        . READ BINARY BLOCK                     01206
         LDA(R)          AJP(6C)         . SENSE END OF PROGRAM                  01207
         LDA(T+7)        STA(C+3)        . ADVANCE BIAS                          01210
         LDA4(3C)        AJP1(5C)        . SENSE COMPLETION OF CALL              01211
         ISK4(7)         SLJ(L-1)        .                                       01212
7C       LDA(2C)         SLJ4(9CA)       . REWIND LIBRARY MEDIUM                 01213
         SLJ4(1V)        ZRO(0)          .                                       01214
         SLJ4(10C)       ZRO(0)          .                                       01215
         SLJ(1C)         ZRO(0)          . EXIT                                  01216
8C       LDA(2C)         SLJ4(9CA)       . REWIND LIBRARY MEDIUM                 01217
         SLJ4(1V)        ZRO(0)          .                                       01220
         SLJ4(10C)       ZRO(0)          .                                       01221
         ENA(E3)         SLJ(2E)         . ERROR EXIT                            01222
9C       ENI1(7)         ENI(0)          .                                       01223
         LDA1(3C)        AJP1(L+2)       .                                       01224
         IJP1(L-1)       SLJ(7C)         .                                       01225
         LDA1(3C)        STA(E7)         .                                       01226
         ENA(0)          STA1(3C)        .                                       01227
         LDA(2C)         SLJ4(9CA)       . REWIND LIBRARY MEDIUM                 01230
         SLJ4(1V)        ZRO(0)          .                                       01231
         SLJ4(10C)       ZRO(0)          .                                       01232
         ENA(E5)         SLJ(2E)         . ERROR EXIT                            01233
9CA      SLJ(N)          SAL(2V)         . RESET 160 LIB CALL LOCK-OUT           01234
         ENA(-0)         STA(1SWT)       .                                       01235
         EXF(53511B)     SLJ(L-2)        .                                       01236

* INITIALIZE FOR NEXT CALL

10C      SLJ(N)          ENA(S)          . EXIT/ENTRY                            01237
         STA(C+2)        ENA(J)          .                                       01240
         STA(C+4)        ENI1(7)         .                                       01241
         ENA(0)          STA1(3C)        .                                       01242
         IJP1(L-1)       STA(Z+47B)      .                                       01243
         SLJ(10C)        ZRO(0)          . EXIT                                  01244

* ERROR MESSAGE HANDLER
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1E     SAU(L+1)        SLJ4(5G)      . INDICATE SYSTEM FAILURE            01245
       ENA(N)          LDQ(3M)       .                                    01246
       QJP2(2E)        SLJ(10M)      . SENSE FULL MONITOR CONTROL         01247
2E     AJP(10M)        LDQ(4K)       . SENSE ERROR EXIT FROM COMPILER     01250
       QJP4(6G)        SLJ4(3E)      . GO OUTPUT ERROR MESSAGE            01251
       EXF(1000B)      SLJ(10M)      . EXIT TO MONITOR                    01252

* OUTPUT PACKED BCD MESSAGE

3E     SLJ(N)          SAU(L+2)      . EXIT/ENTRY                         01253
       ENA(0)          SLJ4(3G)      . GO SENSE CHANNELS INACTIVE         01254
       ENI1(N)         ENI2(0)       . STRING OUT BCD CODE                01255
       ENA(20B)        STA(W)        .                                    01256
       ENA(0)          ENI3(0)       .                                    01257
       LDQ1(Z)         LLS(6)        .                                    01260
       AJP(L+4)        STA2(W+1)     .                                    01261
       ENA(0)          INI2(1)       .                                    01262
       ISK3(7)         SLJ(L+6)      .                                    01263
       INI1(1)         SLJ(L-4)      .                                    01264
       ENA(20B)        STA2(W+1)     .                                    01265
       ISK2(119)       SLJ(L-1)      .                                    01266
       LDA(4K)         SLJ4(1W)      . OUTPUT MESSAGE                     01267
       EXF(1000B)      SLJ(3E)       . EXIT                               01270
       LLS(6)          SLJ(L-8)      .                                    01271

* INPUT INDEX REGISTER LOADER

1G     SLJ(N)          STA(T)        . EXIT/ENTRY                         01272
       LIL1(T)         LDQ1(G0)      . TABLE ITEMS TO INDEX REGISTERS     01273
       QRS(6)          LDL(73)       .                                    01274
       SAL(L+2)        QRS(3)        .                                    01275
       LDL(7B)         SAU(L+1)      .                                    01276
       ENI1(N)         ENI2(N)       .                                    01277
       SLJ(L-6)        ZRO(0)        . EXIT                               01300

* OUTPUT INDEX REGISTER LOADER

2G     SLJ(N)          STA(T)        . EXIT/ENTRY                         01301
       LIL1(T)         LDQ1(G0)      . TABLE ITEMS TO INDEX REGISTERS     01302
       LDL(7B)         SAL(L+2)      .                                    01303
       QRS(3)          LDL(73)       .                                    01304
       SAU(L+1)        ENI2(N)       .                                    01305
       ENI1(N)         SLJ(L-5)      . EXIT                               01306
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* DISASSEMBLE READ BUFFER

3G      SLJ(N)           SIL2(L+10)      . EXIT/ENTRY                     01307
        ENA(R+112)       SAL(L+6)        . DISASSEMBLE CHARACTERS         01310
        ENI2(14)         ENI(0)          .                                01311
        LDQ2(R)          ENI1(0)         .                                01312
        ENA(0)           LLS(6)          .                                01313
        EQS(14B)         SLJ(L+2)        . SENSE ALTERNATE DASH           01314
        ENA(40B)         ENI(0)          .                                01315
        ENI(0)           STA1(N)         . STORE CHARACTER                01316
        ISK1(7)          SLJ(L-4)        . LOOP                           01317
        ENA(8)           RSB(L-2)        .                                01320
        IJP2(L-7)        ENI2(N)         .                                01321
        ENA(0)           STA(R+120)      .                                01322
        SLJ(3G)          ZRO(0)          . EXIT                           01323

* ASSEMBLE WRITE BUFFER

4G      SLJ(N)           ENI1(0)         . EXIT/ENTRY                     01324
        ENA(W)           SAL(L+8)        . ASSEMBLE CHARACTERS            01325
        LDA1(W)          ALS(6)          .                                01326
        ADD1(W+1)        ALS(6)          .                                01327
        ADD1(W+2)        ALS(6)          .                                01330
        ADD1(W+3)        ALS(6)          .                                01331
        ADD1(W+4)        ALS(6)          .                                01332
        ADD1(W+5)        ALS(6)          .                                01333
        ADD1(W+6)        ALS(6)          .                                01334
        ADD1(W+7)        STA(N)          . STORE WORD                     01335
        INI1(7)          RAO(L-1)        .                                01336
        ISK1(119)        SLJ(L-9)        . LOOP                           01337
        SLJ(4G)          ZRO(0)          . EXIT                           01340

* SENSE TYPEWRITER FOR ACTION

5G      SLJ(N)           SLJ4(7G)        . EXIT/ENTRY                     01341
        ENA(T+1)         SLJ4(1FLAG)     .                                01342
        SAL(Z+1)         EXF7(11B)       .                                01343
        EXF(11100B)      ENA(1)          .                                01344
        EXF1(T)          ISK1(100B)      .                                01345
        EXF7(11100B)     SLJ(L+2)        . SENSE CARRIAGE RETURN          01346
        EXF1(T+1)        SLJ(5GEX)       .                                01347
        EXF7(11B)        SLJ(L-2)        . SENSE CHARACTER                01350
        LDA(T)           EXF(10000B)     .                                01351
        INA(-4)          AJP(5GEX)       . SENSE SPACE                    01352
        INA(-36B)        AJP(10M)        . SENSE PERIOD                   01353
        INA(13B)         AJP1(L-8)       . SENSE X                        01354
        ENA(-1)          ENI(0)          .                                01355
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5GEX   EXF(62560B)      SLJ(5G)         .                                01356

5GG    SLJ4(5G)         ZRO(0)          . GO SENSE TYPEWRITER            01357
       SLJ(Z+31B)       ZRO(0)          . RETURN VIA CELL 31             01360

* BCD TYPEWRITER OUTPUT

6G     SLJ(N)           SAL(L+3)        . EXIT/ENTRY                     01361
       ENA(R5)          SLJ4(7G)        . GET CARRIAGE RETURN            01362
       EXF(62540B)      EXF7(21B)       .                                01363
       EXF(21110B)      LDA(N)          . SELECT CHARACTER MODE          01364
       ENI(0)           STA(T+1)        . PICK NEXT WORD                 01365
       ENI2(7)          ENI(0)          .                                01366
       LDQ(T+1)         QLS(6)          .                                01367
       STQ(T+1)         LDL(77B)        .                                01370
       ENQ(0)           AJP(6GEX)       . SENSE END OF CODE              01371
       STA(T)           LIL1(T)         .                                01372
       LDQ1(K0)         QLS(6)          . TABLE LOOKUP                   01373
       LDL(77B)         AJP1(L+4)       .                                01374
       EXF7(11141B)     SLJ(L+6)        . SENSE CARRIAGE DOWN            01375
       ENA(57B)         STA(T)          .                                01376
       SLJ(L+3)         ZRO(0)          .                                01377
       EXF7(11140B)     SLJ(L+3)        . SENSE CARRIAGE UP              01400
       ENA(47B)         STA(T)          .                                01401
       EXF2(T)          EXF7(21B)       . SHIFT CARRIAGE                 01402
       QLS(6)           STQ(T)          .                                01403
       EXF2(T)          EXF7(21B)       . PRINT CHARACTER                01404
       ENI(0)           SLJ4(1DLAY)     . GO SLOW DOWN TYPEWRITER        01405
       IJP2(L-15)       RAO(L-18)       . SENSE END OF WORD              01406
       SLJ(L-19)        ZRO(0)          . LOOP                           01407
6GEX   EXF(62560B)      SLJ(6G)         .                                01410

* COMM FLAG1 SET AND DELAY ROUTINE

1FLAG  SLJ(N)           EXF(62540B)     . SET COMM FLAG1                 01411
       SIU1(L+4)        SLJ4(1DLAY)     . GO DELAY                       01412
       SLJ(L-2)         ZRO(0)          . RETURN                         01413

* TYPEWRITER SLOW-DOWN LOOP

1DLAY  SLJ(N)           SIU1(L+2)       . EXIT/ENTRY                     01414
       ENI1(0)          ISK1(100B)      . DELAY                          01415
       ENI1(N)          SLJ(L-2)        . RE-STORE INDEX / GO EXIT       01416

* TYPEWRITER PRINT ROUTINE
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7G      SLJ(N)          EXF7(21B)       . EXIT/ENTRY                             01417
        ENI(0)          SLJ4(1FLAG)     . GO SET COMM FLAG1                      01420
        SAL(L+5)        EXF(21110B)     .                                        01421
        ENA(T+1)        SAL(Z+2)        .                                        01422
        EXF7(11141B)    SLJ(L+3)        . SENSE CARRIAGE UP                      01423
        ENA(57B)        STA(T)          .                                        01424
        EXF2(T)         EXF7(21B)       . SHIFT CARRIAGE DOWN                    01425
        ENI1(7)         LDQ(N)          . PICK NEXT WORD                         01426
        QLS(6)          LDL(77B)        .                                        01427
        AJP(7GEX)       STA(T)          . SENSE END OF PRINT CODE                01430
        EXF2(T)         EXF7(21B)       . PRINT CHARACTER                        01431
        ENI(0)          SLJ4(1DLAY)     . GO TO SLOW DOWN TYPEWRITE              01432
        IJP1(L-4)       RAO(L-5)        . SENSE EIGHT CHARACTERS                 01433
        SLJ(L-6)        ZRO(0)          . LOOP                                   01434
7GEX    EXF(62560B)     SLJ(7G)         .                                        01435

* ASSIGN TAPE MEDIUM AND/OR SENSE ALL CHANNELS INACTIVE

8G      SLJ(N)          AJP(L+15)       . EXIT/ENTRY                             01436
        EQS(1)          SLJ(L+2)        . SENSE LIBRARY TAPE                     01437
        SLJ(8G)         ZRO(0)          .                                        01440
        SSK(3M)         SLJ(L+3)        . SENSE FULL MONITOR CONTROL             01441
        EQS(2M)         SLJ(L-2)        . SENSE STACKED-JOB MEDIUM               01442
        ENA(27B)        SLJ(8G)         .                                        01443
        LQC(77777B)     STQ(T+1)        .                                        01444
        ALS(24)         ENI1(3)         .                                        01445
        MEQ1(C+8)       SLJ(L+2)        . SENSE PREVIOUS ASSIGNMENT              01446
        LDA1(C+8)       SLJ(L+6)        . NUMBER TO ACCUMULATOR                  01447
        STA(T)          ENI(0)          .                                        01450
        LDL1(C+8)       AJP(L+3)        . SEARCH FOR FREE TAPE                   01451
        ISK1(7)         SLJ(L-1)        .                                        01452
        ENA(27B)        SLJ(8G)         .                                        01453
        LDA(T)          RAD1(C+8)       . NUMBER TO TABLE AND ACCUMULATOR        01454
        EXF7(11B)       SLJ(L)          . SENSE ALL CHANNELS INACTIVE            01455
        EXF7(21B)       SLJ(L)          .                                        01456
        EXF7(31B)       SLJ(L)          .                                        01457
        EXF7(41B)       SLJ(L)          .                                        01460
        EXF7(51B)       SLJ(L)          .                                        01461
        EXF7(61B)       SLJ(L)          .                                        01462
        SCL(T+1)        SLJ(8G)         . EXIT                                   01463

* READ BINARY RECORD

1I      SLJ(N)          STA(1SWT)       . EXIT/ENTRY                             01464
        EXF(63511B)     INA(-2020B)     .                                        01465
        AJP1(L+1)       INA(63B)        . SENSE CARD REFERENCE                   01466
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        INA(2020B)     SLJ4(1G)       . GET NUMERIC DESIGNATOR          01467
        IJP1(3I)       IJP2(2I)       . SENSE NO MEDIUM REFERENCE       01470
        ENA(0)         ENI1(53)       . ENDFILE BLOCK TO BUFFER         01471
        STA1(R)        IJP1(_)        .                                 01472
        LDA(R10)       STA(R)         .                                 01473
        SLJ(1I)        ZRO(0)         . EXIT                            01474
2I      ENA2(-5)       AJP1(5I)       . SENSE MEMORY REFERENCE          01475
        LDA(5S)        INA(-1)        . READ MEMORY RECORD              01476
        SAU(L+2)       ENI(0)         .                                 01477
        LDQ7(6S)       STQ1(R)        .                                 01500
        ISK1(N)        SLJ(L-1)       .                                 01501
        INA(1)         RAD(6S)        .                                 01502
        SLJ(1I)        ZRO(0)         . EXIT                            01503
3I      IJP1(L+1)      SLJ(4I)        . SENSE TAPE REFERENCE            01504
        ENA(10X)       SAL(9X)        . READ TAPE RECORD                01505
        LDA(U1)        ENI(0)         .                                 01506
        IJP1(L+1)      LDA(U0)        .                                 01507
        IJP1(5I)       ARS(24)        .                                 01510
        STA(T)         ENA(R+54)      .                                 01511
        SAU(2X)        SAU(6X)        .                                 01512
        ENA2(0)        ALS(3)         .                                 01513
        ADD(T)         INA(1)         .                                 01514
        SLJ4(1X)       ZRO(0)         .                                 01515
        SLJ(1I)        ZRO(0)         . EXIT                            01516
4I      ENA(14002B)    SLJ4(1FLAG)    . SENSE CARD REFERENCE            01517
        IJP2(L+1)      INA(-1)        .                                 01520
        IJP2(5I)       SAU(L+3)       .                                 01521
        ENA(R)         ENI1(2)        . READ BINARY CARD GROUP          01522
        SAU(L+2)       INA(24)        .                                 01523
        EXF(N)         SAL(Z+1)       .                                 01524
        EXF1(N)        EXF7(24004B)   . READ CARD                       01525
        IJP1(L-3)      ENI(0)         . LOOP                            01526
        ENA(R+54)      SAL(L+1)       . ASSEMBLE EXTRA BITS             01527
        ENI2(4)        LDQ(N)         .                                 01530
        LDA1(R)        QLS(8)         .                                 01531
        ADL(R7)        ENI(0)         . SENSE FOR MINUS ZERO            01532
        AJP1(L+2)      LDL(R7)        .                                 01533
        AJP(L+1)       LDA(-0)        .                                 01534
        STA1(R)        ENI(0)         .                                 01535
        INI1(1)        IJP2(L-5)      .                                 01536
        RAO(L-7)       ENA1(-55)      .                                 01537
        AJP1(L-8)      ENI2(53)       . LOOP                            01540
        ADD2(R)        IJP2(L)        . GET CHECK SUM                   01541
        EXF(70B)       STA(T)         .                                 01542
        ENI1(70)       LDA1(R)        .                                 01543
        LDQ1(R+1)      QLS(8)         .                                 01544
        LLS(40)        SCM(T)         .                                 01545
        AJP(4IEX)      ENI(0)         . CHECK FOR CORRECT READ          01546
        ENA(T0)        SLJ4(5G)       . TROUBLE EXIT                    01547
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        AJP(4IEX)         SLJ(L-22)          . SENSE FOR ACTION TO TAKE           01550
4IEX    EXF(62560B)       SLJ(1I)            .                                    01551
5I      ENA(E9)           SLJ(1E)            . ERROR EXIT                         01552

* SWITCH SELECTION ROUTINE

1J      SLJ(N)            SLJ(L+7)           . EXIT/ENTRY                         01553
        ZRO(0)            ZRO(0)             . ARGUMENTS                          01554
        ZRO(0)            ZRO(0)             .                                    01555
        ZRO(0)            ZRO(0)             .                                    01556
        ZRO(0)            ZRO(0)             .                                    01557
        ZRO(0)            ZRO(0)             .                                    01560
        ZRO(0)            ZRO(0)             .                                    01561
        ENA(0)            ENI1(5)            .                                    01562
        STA1(Z+51B)       IJP1(L)            . CLEAR SIMULATION LOCATIONS         01563
        LDA1(L-8)         ENI2(6)            .                                    01564
        EQS2(F1)          SLJ(L+3)           . SENSE SWITCH SELECTION             01565
        ENA(-0)           STA2(Z+51B)        .                                    01566
        INI1(1)           SLJ(L-3)           .                                    01567
        ENA(0)            ENI1(5)            .                                    01570
        STA1(L-13)        IJP1(L)            . CLEAR ARGUMENTS                    01571
        SLJ(L-15)         ZRO(0)             . EXIT                               01572

* CONTROL INITIALIZER

1K      SLJ(N)            SLJ(L)             . EXIT/ENTRY                         01573
2K      ZRO(0)            ZRO(0)             . CONTROL MEDIUM                     01574
3K      ZRO(0)            ZRO(0)             . CONTROL STATEMENT OUTPUT MEDIUM    01575
4K      ZRO(0)            ZRO(0)             . ERROR OUTPUT MEDIUM                01576

* MONITOR ROUTINE

1M      ENI(0)            SLJ(L+8)           . ENTRY                              01577
2M      ZRO(0)            ZRO(0)             . STACKED-JOB MEDIUM                 01600
3M      ZRO(0)            ZRO(0)             . LISTABLE-OUTPUT MEDIUM             01601
4M      ZRO(0)            ZRO(0)             . COMPILE-MODE INDICATOR             01602
5M      ZRO(0)            ZRO(0)             . JOB-TIME LIMIT                     01603
6M      ZRO(0)            ZRO(0)             . PUNCH-CARD MEDIUM                  01604
7M      ZRO(0)            ZRO(0)             . SOURCE-LANGUAGE INDICATOR          01605
8M      ZRO(0)            ZRO(0)             . INTERMEDIATE-LANGUAGE INDICATOR    01606
        LDA(Z+47B)        AJP(L+4)           . SENSE RECOVERY INDICATOR           01607
        LDA(2M)           SAL(8V)            . BACKSPACE STACKED-JOB MEDIUM       01610
        SLJ4(7V)          ZRO(0)             .                                    01611
        SLJ(L+5)          ZRO(0)             .                                    01612
        LDA(3M)           SAL(2V)            . REWIND LISTABLE-OUTPUT MEDIUM      01613
        SLJ4(1V)          ZRO(0)             .                                    01614
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        LDA(6M)         SAL(2V)       . REWIND PUNCH-CARD MEDIUM              01615
        SLJ4(1V)        ZRO(0)        .                                       01616
        LDA(3M)         INA(-1)       . SENSE INPUT-OUTPUT CONFLICTS          01617
        AJP(1P)         LDA(6M)       .                                       01620
        INA(-1)         AJP(1P)       .                                       01621
        LDA(2M)         EXF(53544B)   . TURN ON REMOTE MONITOR LIGHT          01622
        THS(9)          SLJ(L+4)      .                                       01623
        SUB(3M)         AJP(1P)       .                                       01624
        LDA(2M)         SUB(6M)       .                                       01625
        AJP(1P)         ENI(0)        .                                       01626
        ENI6(1)         SLJ4(10C)     . GO INITIALIZE FOR NEXT CALL           01627
        LDA(2K)         STA(T+9)      .                                       01630
        LDA(3M)         AJP(11M)      . SENSE PARTIAL MONITOR CONTROL         01631
        LDA(2M)         ENI3(0)       .                                       01632
        EQS(63B)        SLJ(L+6)      . SENSE STACKED-JOB DECK                01633
        EXF(62540B)     SLJ4(1G)      . GET NUMERIC DESIGNATOR                01634
        SIL2(T+11)      ENQ(M+63)     .                                       01635
        ENA2(14001B)    SAL(L+1)      .                                       01636
        STQ(Z+1)        EXF(N)        .                                       01637
        EXF1(M+39)      EXF7(24004B)  . READ BCD RECORD                       01640
        THS(9)          SLJ(L+13)     . SENSE STACKED-JOB TAPE                01641
        SLJ4(1R)        ZRO(0)        . GO READ BCD RECORD                    01642
        ENA(M+39)       SAL(L+8)      . ASSEMBLE READ BUFFER                  01643
        LDA3(R)         ALS(6)        .                                       01644
        ADD3(R+1)       ALS(6)        .                                       01645
        ADD3(R+2)       ALS(6)        .                                       01646
        ADD3(R+3)       ALS(6)        .                                       01647
        ADD3(R+4)       ALS(6)        .                                       01650
        ADD3(R+5)       ALS(6)        .                                       01651
        ADD3(R+6)       ALS(6)        .                                       01652
        ADD3(R+7)       STA(N)        . TRANSFER WORD TO MONITOR BUFFER       01653
        INI3(7)         RAO(L-1)      .                                       01654
        ISK3(79)        SLJ(L-9)      . SENSE TEN WORDS TRANSFERRED           01655
        SIL6(2C)        SIL6(R)       .                                       01656
        LDA(4M)         AJP1(11M)     . SENSE INTERMEDIATE COMPILE TAPE       01657
        LDA(R15)        STA(3C)       .                                       01660
        EXF(62560B)     SLJ4(1C)      . LOAD COMPILER                         01661
        SIL6(S+2)       ENA(0)        .                                       01662
        STA(3C)         SLJ(11M)      .                                       01663
9M      LDQ(2M)         QJP(2P)       . SUCCESS RETURN                        01664
10M     EXF(62560B)     EXF(53544B)   . RELEASE COMM FLAG 1                   01665
        LDQ(2M)         QJP(1P)       . ERROR RETURN                          01666
        ENI6(1)         SLJ4(3T)      . GO OUTPUT JOB-TIME                    01667
11M     EXF(62560B)     SLJ4(1J)      . GO RESET SWITCH SIMULATORS            01670
        ENI2(7)         EXF(53511B)   .                                       01671
        ENA(-0)         STA(1SWT)     . RE-SET 160 LIB CALL LOCK-OUT          01672
        ENI1(7)         ENA(0)        .                                       01673
        SAU2(C+8)       IJP2(_)       . RESET TAPE-ASSIGNMENT TABLE           01674
        LDA(3M)         AJP(L+2)      .                                       01675
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      STA(4K)        ENI(0)            .
      EQS1(C+9)      SLJ(L+2)          . SENSE LISTABLE-OUTPUT TAPE
      ENA(-0)        SAU1(C+9)         . CANCEL LISTABLE-OUTPUT TAPE
      LDA(2M)        ENI1(7)           .
      EQS1(C+9)      SLJ(L+2)          . SENSE STACKED-JOB TAPE
      ENA(-0)        SAU1(C+9)         . CANCEL STACKED-JOB TAPE
      LDA(6M)        ENI1(7)           .
      EQS1(C+9)      SLJ(L+2)          . SENSE PUNCH-CARD TAPE
      ENA(-0)        SAU1(C+9)         . CANCEL PUNCH-CARD TAPE
      ENA(0)         STA(CANCEL)       . CANCEL UNASSIGNED UNITS
      ENA(32001B)    SAL(L+3)          .
      SAU(L+4)       ENI1(1)           .
      ENA(10B)       RAD(L+1)          .
      ENI2(0)        EXF(32001B)       .
      RAO(CANCEL)    ISK2(3000B)       .
      EXF7(32001B)   SLJ(L+3)          .
      ENA(77777B)    ENI(0)            .
      LIL2(CANCEL)   SAU2(C+7)         .
      ISK1(4B)       SLJ(L-6)          .
      ENA(52001B)    SAU(L-9)          .
      LIL2(CANCEL)   ENI(0)            .
      ISK2(10B)      SLJ(L-11)         .
      ENA(-0)        SAU(C+15)         . CANCEL GRAPH OUTPUT TAPE
      ENA(32001B)    SAU(L-13)         .
      EXF(70B)       LDA(R12)          . RESET TIME
      STA(Z)         ENA(0)            .
      LDQ(4M)        QJP(L+2)          . INSURE INTERMEDIATE TAPE RESET
      LIL1(4M)       SAU1(C+7)         .
      STA(Z+50B)     EXF(100B)         .
      EXF(1000B)     LDQ(5M)           .
      QJP(L+2)       STQ(5T)           . SENSE JOB-TIME LIMIT
      STA(6T)        SLJ4(4T)          . SET JOB-TIME LIMIT
      ENI1(119)      ENQ(20B)          .
      LDA1(R)        STA1(W+1)         . TRANSFER READ TO WRITE BUFFER
      IJP1(L-1)      STQ(W)            .
      ADD(R+1)       INA(-166B)        .
11MAA AJP(L+2)       SLJ4(Z+11B)       . SENSE JOB-DESCRIPTION RECORD
      SLJ(L-5)       ZRO(0)            . RETURN FOR NEXT RECORD
11MA  SSK(0SWT)      SLJ4(1SWTH)       . GO PROCESS SATELLITE JOB
      ENA(-0)        STA(7M)           . CLEAR SOURCE INDICATOR
      STA(8M)        ENI(0)            . CLEAR MAP INDICATOR
      LDA(R+5)       INA(-54B)         . SENSE DESIRE SOURCE LIST
      AJP1(L+1)      RAO(7M)           . SET SOURCE INDICATOR
      LDA(R+6)       INA(-54B)         . SENSE DESIRE MAP LIST
      AJP1(L+1)      RAO(8M)           . SET MAP INDICATOR
      ENA(23B)       SLJ4(1W)          . TYPE JOB-DESCRIPTION RECORD
      SIL6(2C)       SIL6(W)           .
      LDA(3M)        AJP1(L+3)         . SENSE JOB-INCORPORATED CONTROL
      LDA(3K)        SLJ4(1W)          .
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         SLJ(L+2)        ZRO(0)         .                                   01757
         SLJ4(Z+12B)     ZRO(0)         . STACK JOB-DESCRIPTION RECORD      01760
         LDA(6M)         AJP(12M)       . SENSE PUNCH-CARD MEDIUM           01761
         ENA(0)          SLJ4(3G)       . SENSE ALL CHANNELS INACTIVE       01762
         ENI1(119)       LDA(6M)        .                                   01763
         LDQ1(R)         STQ1(W)        . TRANSFER READ TO WRITE BUFFER     01764
         IJP1(L-1)       SLJ4(1W)       . STACK JOB-DESCRIPTION RECORD      01765
12M      LDA(R+2)        ALS(6)         .                                   01766
         ADD(R+3)        INA(-6545B)    .                                   01767
         AJP1(13M)       LDA(R+4)       .                                   01770
         INA(-64B)       AJP1(13M)      . SENSE END OF JOB-STACK            01771
         EXF(101B)       EXF(2000B)     . STOP CLOCK                        01772
         LDA(3M)         SAL(6V)        .                                   01773
         SLJ4(5V)        ZRO(0)         . ENDFILE LISTABLE-OUTPUT MEDIUM    01774
         LDA(6M)         SAL(6V)        .                                   01775
         SLJ4(5V)        ZRO(0)         . ENDFILE PUNCH-CARD MEDIUM         01776
         LDA(3M)         SAL(4V)        .                                   01777
         THS(9)          SLJ(L+2)       . SENSE LISTABLE-OUTPUT TAPE        02000
         SLJ4(3V)        ZRO(0)         . REWIND LISTABLE-OUTPUT TAPE       02001
         LDA(6M)         SAL(4V)        .                                   02002
         THS(9)          SLJ(L+2)       . SENSE PUNCH-CARD TAPE             02003
         SLJ4(3V)        ZRO(0)         . REWIND PUNCH-CARD TAPE            02004
         ENA(-0)         STA(2M)        . CANCEL MONITOR CONTROL            02005
         LDA(T+9)        STA(2K)        .                                   02006
         ENA(1)          SAL(2V)        . REWIND LIBRARY TAPE               02007
         SLJ4(1V)        ZRO(0)         .                                   02010
         LDA(R+5)        INA(31B)       .                                   02011
         EQS(65B)        SLJ(2P)        . SENSE SWITCH-BACK TO MONITOR      02012
         STA(R)          STA(R+1)       .                                   02013
         SLJ(3P)         ZRO(0)         . GO TO EXECUTE MONITOR             02014
13M      LDA(4M)         AJP1(15M)      . SENSE INTERMEDIATE COMPILE TAPE   02015
         LDA(3M)         AJP1(14M)      . SENSE JOB-INCORPORATED CONTROL    02016
         LDA(2M)         STA(2K)        .                                   02017
         ENA(-0)         STA(3M)        .                                   02020
         STA(6M)         ENI(0)         .                                   02021
         EXF(70B)        SLJ(2P)        . RETURN FOR CONTROL STATEMENT      02022
14M      LDA(7M)         STA(S+4)       . RUN IN FORTRAN-TO-MEMORY MODE     02023
         LDA(8M)         STA(S+6)       .                                   02024
         SLJ4(S)         ZRO(0)         . COMPILE TO MEMORY                 02025
         ENA(-0)         SAU(C+8)       . CANCEL LIBRARY TAPE               02026
         STA(1SWT)       EXF(53511B)    . RE-SET 160 LIB CALL LOCK-OUT      02027
         EXF(70B)        SLJ4(S+14000B) . EXECUTE OBJECT PROGRAM            02030
         EXF(70B)        SLJ(9M)        . RETURN FOR NEXT JOB               02031
15M      LDA(R15)        STA(3C)        . RUN IN FORTRAN-TO-TAPE MODE       02032
         SLJ4(1C)        ZRO(0)         . LOAD COMPILER                     02033
         SIL6(S+2)       LDA(4M)        .                                   02034
         STA(S+3)        ENI1(7)        .                                   02035
         EQS1(C+9)       SLJ(1P)        .                                   02036
         SAU1(C+9)       ENI(0)         . CANCEL INTERMEDIATE TAPE          02037
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         SLJ4(Z+16B)    ZRO(0)         . REWIND INTERMEDIATE TAPE        02040
         LDA(7M)        STA(S+4)       .                                 02041
         LDA(8M)        STA(S+6)       .                                 02042
         SLJ4(S)        ZRO(0)         . COMPILE TO TAPE                 02043
         LIL6(4M)       SIL6(2C)       .                                 02044
         ENA6(0)        SLJ4(Z+16B)    . REWIND INTERMEDIATE TAPE        02045
         ENA(0)         SAU6(C+7)      . RELEASE INTERMEDIATE TAPE       02046
         STA(3C)        SLJ4(1C)       . CALL OBJECT PROGRAM             02047
         ENA(-0)        SAU(C+8)       . CANCEL LIBRARY TAPE             02050
         STA(1SWT)      EXF(53511B)    . RE-SET 160 LIB CALL LOCK-OUT    02051
         EXF(70B)       SLJ4(S)        . EXECUTE OBJECT PROGRAM          02052
         EXF(70B)       SLJ(9M)        . RETURN FOR NEXT JOB             02053

* WRITE BINARY RECORD

10       SLJ(N)         INA(-2020B)    . EXIT/ENTRY                      02054
         AJP1(L+1)      ENA(63B)       . SENSE CARD REFERENCE            02055
         INA(2020B)     SLJ4(2G)       . GET NUMERIC DESIGNATOR          02056
         IJP1(30)       IJP2(20)       .                                 02057
         SLJ(10)        ZRO(0)         . EXIT                            02060
20       ENA2(-5)       AJP1(50)       . SENSE MEMORY REFERENCE          02061
         LDA(5S)        INA(-1)        . WRITE MEMORY RECORD             02062
         SAU(L+2)       INA(1)         .                                 02063
         LDQ1(W)        STQ7(5S)       .                                 02064
         ISK1(N)        SLJ(L-1)       .                                 02065
         RAD(6S)        SLJ(1D)        . EXIT                            02066
30       IJP1(L+1)      SLJ(4D)        . SENSE TAPE REFERENCE            02067
         LDA(U1)        ENI(0)         . WRITE TAPE RECORD               02070
         IJP1(L+1)      LDA(UD)        .                                 02071
         IJP1(10)       ENI(0)         .                                 02072
         STA(T+10)      ENA(W+54)      .                                 02073
         SAU(3Y)        ENA2(0)        .                                 02074
         ALS(3)         INA(1)         .                                 02075
         ADD(T+10)      SLJ4(1Y)       .                                 02076
         SLJ(10)        ZRO(0)         . EXIT                            02077
40       ENA2(-2)       SLJ4(1FLAG)    . SENSE CARD REFERENCE            02100
         AJP1(50)       EXF7(24004B)   . SENSE CARD REFERENCE            02101
         ENI2(0)        ISK2(1000B)    . DELAY                           02102
         ENA(W+24)      ENI2(17)       . PUNCH BINARY CARD GROUP         02103
         EXF(24004B)    SAL(Z+2)       .                                 02104
         EXF2(W)        ENA(0)         . PUNCH CARD ONE                  02105
         STA2(W+54)     IJP2(L)        . CLEAR                           02106
         ENI2(0)        ISK2(1000B)    . DELAY                           02107
         ENI1(71)       ENI2(53)       .                                 02110
         ADD2(W)        IJP2(L)        . GET CHECK SUM                   02111
         EXF(70B)       STA1(W)        . STORE LOW ORDER PART            02112
         INI1(-1)       ENQ(-0)        .                                 02113
         LLS(8)         STQ1(W)        . STORE HIGH ORDER PART           02114
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         ENA(W+48)          EXF7(24004B)       .                                 02115
         EXF(24004B)        SAL(Z+2)           .                                 02116
         EXF2(W+24)         ENI1(0)            . PUNCH CARD TWO                  02117
         ENA(W)             SAU(L+3)           . ASSEMBLE EXTRA BITS             02120
         ENI2(0)            ISK2(1000B)        . DELAY                           02121
         ENI2(0)            ENA(0)             .                                 02122
         LDQ2(N)            LLS(8)             .                                 02123
         ISK2(4)            SLJ(L-1)           .                                 02124
         STA1(W+54)         ENA(5000B)         .                                 02125
         ALS(15)            RAD(L-3)           .                                 02126
         ISK1(10)           SLJ(L-5)           .                                 02127
         LDA1(W+48)         STA1(M+15)         . TRANSFER TO BUFFER              02130
         ISK1(23)           SLJ(L-1)           .                                 02131
         ENA(M+39)          EXF7(24004B)       .                                 02132
         EXF(24004B)        SAL(Z+2)           .                                 02133
         EXF2(M+15)         EXF7(24004B)       . PUNCH CARD THREE                02134
60       EXF(62560B)        SLJ(10)            .                                 02135
50       ENA(E12)           SLJ(1E)            . ERROR EXIT                      02136

* PROGRAM CONTROL ROUTINE

1P       ENA(0)             STA(2K)            . SET CONTROL AT TYPEWRITER       02137
2P       EXF(53511B)        EXF(63544B)        . FORTRAN ON / MONITOR OFF        02140
         ENA(-0)            STA(1SWT)          . RE-SET 160 LIB CALL LOCK-OUT    02141
         LDA(2K)            AJP1(4P)           . SENSE TYPEWRITER CONTROL        02142
         EXF(2000B)         EXF(11100B)        . SELECT TYPEWRITER               02143
         ENA(0)             ENI2(120)          .                                 02144
         STA2(R)            IJP2(L)            . CLEAR BUFFER                    02145
         ENA(T+1)           SAL(Z+1)           .                                 02146
         EXF1(T)            ISK1(100B)         . READ CHARACTER                  02147
         EXF7(11101B)       SLJ(2P)            . SENSE CARRIAGE RETURN           02150
         EXF7(11B)          SLJ(L-1)           . SENSE CHARACTER                 02151
         LIL1(T)            LDQ1(K0)           . TABLE LOOKUP                    02152
         EXF7(11141B)       QLS(6)             . SHIFT ON LOWER CASE             02153
         QLS(30)            LDL(77B)           .                                 02154
         STA2(R)            INA(-73B)          .                                 02155
         INI2(1)            AJP3(L-7)          . LOOP UNTIL PERIOD OR OPEN PAREN 02156
         EXF(1000B)         STA(3K)            .                                 02157
         STA(4K)            ENI(0)             .                                 02160
         ENA(20B)           STA2(R)            .                                 02161
         ISK2(120)          SLJ(L-1)           .                                 02162
3P       LDA(R11)           STA(Z+57B)         . NULLIFY LIMIT AT 57             02163
         ENA(-0)            ENI1(6)            . CANCEL MONITOR CONTROL          02164
         STA1(2M)           IJP1(L)            .                                 02165
         SLJ(L+2)           ZRO(0)             .                                 02166
4P       LDA(2K)            SLJ4(1R)           . READ CONTROL STATEMENT          02167
         ENI1(71)           ENI2(47)           .                                 02170
         LDA1(R)            STA1(W)            . COPY BUFFER                     02171
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      IJP1(L-1)     ENA(20B)      .                                       02172
      STA2(W+72)    IJP2( )       .                                       02173
      LDA(3K)       AJP5(1W)      . OUTPUT STATEMENT IF INDICATED         02174
      ENA(73B)      ENI4(0)       .                                       02175
      EQS(R)        SLJ(L+3)      . SENSE DOUBLE PERIOD                   02176
      EQS(R+1)      SLJ(4P)       .                                       02177
      SLJ(10M)      ZRO(0)        .                                       02200
      LDA4(R)       INA(-54B)     .                                       02201
      AJP1(L+1)     INI4(1)       . SENSE ASTERISK                        02202
      LDA4(R)       ENI1(26)      .                                       02203
      EQS1(F12)     SLJ(9M)       . SENSE LETTER                          02204
      ENA(0)        STA(T)        .                                       02205
      LDA4(R)       ENI1(36)      .                                       02206
      EQS1(F0)      SLJ(L+4)      . ASSEMBLE NAME                         02207
      LDA(T)        ALS(6)        .                                       02210
      ADD4(R)       STA(T)        .                                       02211
      INI4(1)       SLJ(L-4)      .                                       02212
      SUB(20B)      AJP(L-1)      .                                       02213
      LDA(T)        ENQ(0)        . POSITION NAME                         02214
      LRS(6)        AJP1(L)       .                                       02215
      LDL(-0B)      LIL3(L+5)     .                                       02216
      EQS3(P0)      SLJ(5P)       . SEARCH CALLED PROGRAMS                02217
      ENA3(-7)      AJP2(L+2)     . SENSE MONITOR-RESTRICTED GROUP        02220
      SSK(2M)       SLJ(2P)       . SENSE NO MONITOR CONTROL              02221
      LDA3(0Z)      SAL(L+3)      .                                       02222
      SAL(7P)       ARS(24)       .                                       02223
      STA(8P)       SLJ4(6P)      .                                       02224
      EXF(70B)      SLJ4(N)       . EXECUTE PROGRAM                       02225
      EXF(70B)      SLJ(2P)       . RETURN FOR CONTROL STATEMENT          02226
5P    EQS(R17)      SLJ(L+6)      . SENSE REMARK                          02227
      ENI1(79)      ENA(23B)      .                                       02230
      LDQ1(R)       STQ1(W)       .                                       02231
      IJP1(L-1)     SLJ4(1W)      . TYPE REMARK                           02232
      ENA(R5)       SLJ4(5G)      .                                       02233
      SLJ(2P)       ZRO(0)        . RETURN FOR CONTROL STATEMENT          02234
      ENA(E0)       SLJ(1E)       . ERROR EXIT                            02235
6P    SLJ(N)        SLJ(L+3)      . PROCESS ARGUMENTS                     02236
7P    ZRO(0)        ZRO(0)        . NEXT ARGUMENT ADDRESS                 02237
8P    ZRO(0)        ZRO(0)        . NUMBER OF ARGUMENTS                   02240
9P    LDA4(R)       AJP(11P)      .                                       02241
      INA(-33B)     AJP(L+5)      . SENSE COMMA OR OPEN PAREN             02242
      INA(-1)       AJP(L+4)      .                                       02243
      INA(-37B)     AJP(6P)       . SENSE PERIOD OR CLOSED PAREN          02244
      INA(-1)       AJP(6P)       .                                       02245
      SLJ(11P)      ZRO(0)        .                                       02246
      INI4(1)       LDA4(R)       . SKIP SPACES                           02247
      SUB(20B)      AJP(L-1)      .                                       02250
      ENA(0)        STA(T)        . CLEAR ASSEMBLY                        02251
      LDA4(R)       ENI1(3)       .                                       02252
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         EQS1(FO)          SLJ(L+6)        . SENSE OCTAL NUMBER              02253
         LDA4(R)           ENI1(3)         .                                 02254
         EQS1(FO)          SLJ(10P)        .                                 02255
         LDA(T)            ALS(3)          . ASSEMBLE NUMBER                 02256
         INA1(0)           STA(T)          .                                 02257
         INI4(1)           SLJ(L-4)        . LOOP                            02260
         LDA4(R)           ENI1(36)        .                                 02261
         EQS1(FO)          SLJ(L+4)        .                                 02262
         LDA(T)            ALS(6)          . ASSEMBLE NAME                   02263
         ADD4(R)           STA(T)          .                                 02264
         INI4(1)           SLJ(L-4)        . LOOP                            02265
         SUB(20B)          AJP(L-1)        .                                 02266
10P      RAO(7P)           RSO(8P)         .                                 02267
         AJP3(11P)         LDA(T)          . SENSE ARGUMENT LIMIT            02270
         STA7(7P)          SLJ(9P)         . LOOP                            02271
11P      ENA(E18)          SLJ(1E)         . ERROR EXIT                      02272

* EXECUTE LAST ASSEMBLED PROGRAM

1Q       ENI(0)            LIL1(C+5)       . ENTRY                           02273
         INI1(-1)          LDA1(0Z)        .                                 02274
         SAU(L+1)          ENI(0)          .                                 02275
         SLJ4(N)           ZRO(0)          . EXECUTE PROGRAM                 02276
         SLJ(9M)           ZRO(0)          . RETURN TO MONITOR               02277

* HOLD ROUTINE

2Q       SLJ(N)            LDA(C+5)        . EXIT/ENTRY                      02300
         STA(C+4)          LDA(C+3)        .                                 02301
         STA(C+2)          ENA(1)          .                                 02302
         STA(Z+47B)        SLJ(L-3)        . EXIT                            02303

* CLEAR ROUTINE

3Q       SLJ(N)            SLJ4(10C)       . EXIT/ENTRY                      02304
         ENA(0)            STA1(S)         .                                 02305
         ISK1(77776B)      SLJ(L-1)        .                                 02306
         SLJ(L-3)          ZRO(0)          . EXIT                            02307

* SKIP TO NEXT OR SPECIFIED JOB

4Q       SLJ(N)            SLJ(L+3)        . EXIT/ENTRY                      02310
         ZRO(0)            ZRO(0)          . MEDIUM                          02311
         ZRO(0)            ZRO(0)          . CHARACTERS IDENTIFYING JOB      02312
         LDA(L-2)          SLJ4(1R)        . READ RECORD                     02313
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        LDA(R)           ADD(R+1)         .                                   02314
        INA(-166B)       AJP3(L-2)        . SENSE DOUBLE PERIOD               02315
        LDA(L-4)         AJP(L-6)         . SENSE SPECIFIC JOB REQUEST        02316
        ENI1(0)          ENQ(77B)         . ACCUMULATE CHARACTERS             02317
        ENA(0)           ENI(0)           .                                   02320
        ALS(6)           ADL1(R+2)        .                                   02321
        EQS(L-8)         SLJ(L+3)         . SENSE SPECIFIC JOB                02322
        ENA(0)           STA(L-9)         .                                   02323
        SLJ(L-12)        ZRO(0)           . EXIT                              02324
        ISK1(7)          SLJ(L-4)         . SENSE EIGHT CHARACTERS            02325
        SLJ(L-11)        ZRO(0)           . RETURN                            02326

* BCD READ ROUTINE

1R      SLJ(N)           SLJ4(1G)         . EXIT/ENTRY                        02327
        IJP1(L+10)       IJP2(L+6)        . SENSE NO MEDIUM REFERENCE         02330
        ENA(0)           ENI1(119)        . ENDFILE BLOCK TO BUFFER           02331
        STA1(R+1)        ENA(20B)         .                                   02332
        STA1(R)          IJP1(L)          .                                   02333
        ENA(73B)         STA(R)           . ENTER DOUBLE PERIOD               02334
        STA(R+1)         SLJ(1R)          . EXIT                              02335
        IJP2(L+1)        SLJ(6R)          . SENSE TYPEWRITER INPUT            02336
        IJP2(L+1)        SLJ(7R)          . SENSE PAPER TAPE INPUT            02337
        ENA2(-3)         AJP(8R)          . SENSE MEMORY INPUT                02340
        SLJ(5R)          ZRO(0)           .                                   02341
        IJP1(9R)         ENI(0)           . SENSE MAGNETIC TAPE INPUT         02342
        ENI(0)           ENA(14002B)      . SENSE CARD INPUT                  02343
        IJP2(L+1)        INA(-1)          .                                   02344
        SAU(L+1)         IJP2(5R)         .                                   02345
2R      EXF(N)           SLJ4(1FLAG)      . PROCESS CARD READER               02346
        ENA(R+104)       SAL(Z+1)         .                                   02347
        EXF1(R+80)       EXF7(14004B)     . READ CARD                         02350
        EXF(62560B)      SLJ4(3R)         . GO PROCESS CARD IMAGE             02351
        ENI(0)           ENI1(79)         .                                   02352
        LDA1(R)          ENI2(47)         .                                   02353
        EQS2(F0)         SLJ(L+2)         . SENSE VALID CODES                 02354
        IJP1(L-2)        SLJ(1R)          . EXIT                              02355
        EQS(14B)         SLJ(L+3)         . SENSE ALTERNATE DASH              02356
        ENA(40B)         STA1(R)          .                                   02357
        SLJ(L-3)         ZRO(0)           .                                   02360
        ENA(T3)          SLJ4(5G)         . TROUBLE EXIT                      02361
        AJP(1R)          SLJ(2R)          . SENSE FOR ACTION TO TAKE          02362
3R      SLJ(N)           ENI1(80)         . PROCESS CARD IMAGE                02363
        ENA(0)           ENI2(79)         . CLEAR BUFFER                      02364
        STA2(R)          IJP2(L)          .                                   02365
        ENA(60B)         SLJ4(4R)         . PROCESS ROWS                      02366
        ENA(40B)         SLJ4(4R)         .                                   02367
        ENA(20B)         SLJ4(4R)         .                                   02370
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      ENA(1)           SLJ4(4R)        .                                02371
      ENA(2)           SLJ4(4R)        .                                02372
      ENA(3)           SLJ4(4R)        .                                02373
      ENA(4)           SLJ4(4R)        .                                02374
      ENA(5)           SLJ4(4R)        .                                02375
      ENA(6)           SLJ4(4R)        .                                02376
      ENA(7)           SLJ4(4R)        .                                02377
      ENA(8)           SLJ4(4R)        .                                02400
      ENA(9)           SLJ4(4R)        .                                02401
      ENA(20B)         ENI1(80)        .                                02402
      EQS1(R)          SLJ(L+3)        . CORRECT ZERO CODES             02403
      ENA(12B)         STA1(R)         .                                02404
      ENA(20B)         SLJ(L-2)        . LOOP                           02405
      ENA(0)           ENI1(80)        .                                02406
      EQS1(R)          SLJ(L+3)        . CORRECT BLANK CODES            02407
      ENA(20B)         STA1(R)         .                                02410
      ENA(0)           SLJ(L-2)        . LOOP                           02411
      ENI1(39)         ENA(20B)        . FILL OUT BLANKS                02412
      STA1(R+80)       IJP1(L)         .                                02413
      ENA(0)           STA(R+120)      .                                02414
      SLJ(3R)          ZRO(0)          . RETURN                         02415
4R    SLJ(N)           STA(T)          . ROW PROCESSOR                  02416
      LDA1(R)          ALS(8)          .                                02417
      STA1(R)          ENI2(39)        .                                02420
      SSH1(R)          SLJ(L+2)        .                                02421
      LDA(T)           RAD2(R)         .                                02422
      ENI(0)           IJP2(L-2)       .                                02423
      LDA1(R+1)        ALS(8)          .                                02424
      STA1(R+1)        ENI2(39)        .                                02425
      SSH1(R+1)        SLJ(L+2)        .                                02426
      LDA(T)           RAD2(R+40)      .                                02427
      ENI(0)           IJP2(L-2)       .                                02430
      INI1(2)          SLJ(4R)         . RETURN                         02431
5R    ENA(E9)          SLJ(1E)         . ERROR EXIT                     02432
6R    EXF(11100B)      SLJ4(1FLAG)     . PROCESS TYPEWRITER             02433
      ENA(T+1)         SAL(Z+1)        .                                02434
      ENI2(0)          ENI1(119)       .                                02435
      EXF1(T)          ENA(0)          .                                02436
      STA1(R+1)        ENA(20B)        .                                02437
      STA1(R)          IJP1(L)         . CLEAR BUFFER                   02440
      EXF1(T)          ISK1(100B)      .                                02441
      EXF7(11101B)     SLJ(L+7)        . SENSE CARRIAGE RETURN          02442
      EXF7(11B)        SLJ(L-1)        . LOOP TO CHARACTERS             02443
      LIL1(T)          LDQ1(K0)        . TABLE LOOKUP                   02444
      EXF7(11141B)     QLS(6)          . SHIFT ON LOWER CASE            02445
      QLS(30)          LDL(77B)        .                                02446
      STA2(R)          ENI(0)          . STORE IN BUFFER                02447
      ISK2(119)        SLJ(L-7)        . LOOP                           02450
      EXF1(T+1)        EXF(11100B)     .                                02451
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        ENA2(0)        AJP(L-9)       . LOOP ON BLANK ENTRY           02452
        INI2(-1)       LDA2(R)        .                               02453
        SUB(20B)       AJP1(L+2)      . SENSE TERMINAL SPACE          02454
        SLJ(L-16)      ZRO(0)         .                               02455
        EXF(62560B)    ENI(0)         .                               02456
        EXF(10000B)    SLJ(1R)        . EXIT                          02457
7R      ENI(0)         SLJ(L+2)       . PROCESS PAPER TAPE            02460
        ZRO(0)         ZRO(0)         . CURRENT CASE                  02461
        ENA(0)         SLJ4(1FLAG)    .                               02462
        EXF(11200B)    ENI2(119)      .                               02463
        STA2(R+1)      ENA(20B)       .                               02464
        STA2(R)        IJP2(L)        . CLEAR BUFFER                  02465
        ENA(T+1)       SAL(Z+1)       .                               02466
7RA     EXF1(T)        EXF7(11B)      . READ CHARACTER                02467
        LDA(T)         AJP(L-1)       . SENSE BLANK CHARACTER         02470
        INA(-43B)      AJP(L-2)       . SENSE STOP CODE               02471
        INA(-34B)      AJP(L-3)       . SENSE DELETE CODE             02472
        LDA(T)         INA(-57B)      .                               02473
        AJP(L+2)       INA(10B)       .                               02474
        AJP1(L+2)      ENA(-0)        .                               02475
        STA(L-13)      SLJ(L-7)       . LOOP                          02476
        INA(47B)       ENI(0)         .                               02477
        EQS(51B)       SLJ(L+2)       .                               02500
        ENI2(6)        SLJ(L-10)      . PROCESS TAB                   02501
        INA(-45B)      AJP(L+7)       . SENSE CARRIAGE RETURN         02502
        LIL1(T)        LDQ1(K0)       . TABLE LOOKUP                  02503
        SSK(L-19)      QLS(6)         . SHIFT ON LOWER CASE           02504
        QLS(42)        LDL(77B)       .                               02505
        STA2(R)        INI2(1)        . STORE IN BUFFER               02506
        ENA2(-81)      AJP(7R)        . RETURN ON BUFFER LIMIT        02507
        SLJ(L-17)      ZRO(0)         .                               02510
        ENA2(0)        AJP(L-19)      . LOOP ON BLANK ENTRY           02511
        EXF(62560B)    SLJ(1R)        . EXIT                          02512
8R      ENI(0)         LDA(5S)        . PROCESS MEMORY                02513
        INA(-1)        SAU(L+2)       .                               02514
        LDQ7(6S)       STQ1(R)        .                               02515
        ISK1(N)        SLJ(L-1)       .                               02516
        INA(1)         RAD(6S)        .                               02517
        SLJ4(3G)       ZRO(0)         . DISASSEMBLE READ BUFFER       02520
        EXF(62560B)    SLJ(1R)        . EXIT                          02521
9R      ENA(16X)       SAL(9X)        . PROCESS MAGNETIC TAPE         02522
        LDA(U1)        ENI(0)         .                               02523
        IJP1(L+1)      LDA(U0)        .                               02524
10R     STA(T+10)      ENA(R+15)      .                               02525
        IJP1(5R)       SAU(2X)        .                               02526
        SAU(6X)        LDA(T+10)      .                               02527
        ARS(24)        STA(T+10)      .                               02530
        ENA2(0)        ALS(3)         .                               02531
        INA(2)         ADD(T+10)      .                               02532
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        SLJ4(1X)            ZRO(0)              .                                  02533
        SLJ4(3G)            ZRO(0)              . DISASSEMBLE READ BUFFER          02534
        SLJ(1R)             ZRO(0)              . EXIT                             02535

* INPUT MEDIUM DESIGNATOR

1S      SLJ(N)              SLJ(L+3)            . EXIT/ENTRY                       02536
        ZRO(0)              ZRO(0)              . SYMBOL                           02537
        ZRO(0)              ZRO(0)              . DEVICE                           02540
        LIL1(L-2)           ENQ(77B)            .                                  02541
        LDL(L-2)            ALS(6)              .                                  02542
        ENQ(70077B)         SSU1(G0)            .                                  02543
        STA1(G0)            SLJ(1S)             . EXIT                             02544

* OUTPUT MEDIUM DESIGNATOR

2S      SLJ(N)              SLJ(L+3)            . EXIT/ENTRY                       02545
        ZRO(0)              ZRO(0)              . SYMBOL                           02546
        ZRO(0)              ZRO(0)              . DEVICE                           02547
        LIL1(L-2)           ENQ(77B)            .                                  02550
        LDL(L-2)            ENQ(77700B)         .                                  02551
        SSU1(G0)            STA1(G0)            .                                  02552
        SLJ(2S)             ZRO(0)              . EXIT                             02553

* SET START OF MEMORY FILE

3S      SLJ(N)              SLJ(L+4)            . EXIT/ENTRY                       02554
4S      ZRO(0)              ZRO(S)              . START OF MEMORY FILE             02555
5S      ZRO(0)              ZRO(0)              . MEMORY RECORD LENGTH             02556
6S      ZRO(0)              ZRO1(S)             . END OF MEMORY FILE               02557
        LDA(4S)             SAL(6S)             . SAVE START OF MEMORY FILE        02560
        LDA(5S)             AJP1(3S)            . SENSE RECORD LENGTH              02561
        ENA(15)             STA(5S)             . SET RECORD LENGTH TO FIFTEEN     02562
        SLJ(3S)             ZRO(0)              . EXIT                             02563

* CLOCK ROUTINE

1T      SLJ(N)              LDA(R11)            . EXIT/ENTRY                       02564
        STA(Z+57B)          LDA(R12)            . RESET LIMIT AT 57                02565
        STA(Z)              ENA(0)              . SET ONE-SECOND COUNT             02566
        STA(Z+50B)          EXF(100B)           . RESET TIME AT 50                 02567
        EXF(1000B)          SLJ(1T)             . EXIT                             02570

* STOP CLOCK ROUTINE
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2T      SLJ(N)          EXF(101B)       . EXIT/ENTRY                    02571
        EXF(2000B)      SLJ(2T)         . EXIT                          02572

* TIME ROUTINE

3T      SLJ(N)          SLJ4(7T)        . EXIT/ENTRY                    02573
        LDA(Z+50B)      ENQ(0)          .                               02574
        DVI(60)         STQ(T+10)       .                               02575
        SLJ4(L+8)       ZRO(0)          . GET MINUTES                   02576
        ADD(R13)        STA(E21)        .                               02577
        LDA(T+10)       SLJ4(L+6)       . GET SECONDS                   02600
        ADD(R14)        STA(E23)        .                               02601
        ENA(E21)        LDQ(2M)         .                               02602
        QJP(L+1)        LDQ(4K)         .                               02603
        QJP4(6G)        SLJ4(3E)        .                               02604
        SLJ(3T)         ZRO(0)          .                               02605
        SLJ(N)          ENI2(0)         . CONVERT NUMBER TO BCD         02606
        THS(100)        INI2(1)         .                               02607
        THS(10)         INI2(1)         .                               02610
        LDQ(R6)         STQ(T)          .                               02611
        ENQ(0)          DVI2(R0)        .                               02612
        SAL(T+1)        LIL1(T+1)       .                               02613
        LDA(T)          ALS(6)          .                               02614
        SCL(77B)        ADD1(F0)        .                               02615
        STA(T)          LLS(48)         .                               02616
        IJP2(L-5)       LDA(T)          .                               02617
        SLJ(L-10)       ZRO(0)          . RETURN                        02620

* LIMIT ROUTINE

4T      SLJ(N)          SLJ(L+3)        . EXIT/ENTRY                    02621
5T      ZRO(0)          ZRO(0)          . MINUTES                       02622
6T      ZRO(0)          ZRO(0)          . SECONDS                       02623
        SLJ4(7T)        ZRO(0)          .                               02624
        LDA(5T)         MUI(60)         . COMPUTE AND SET LIMIT         02625
        ADD(6T)         ADD(Z+50B)      .                               02626
        STA(Z+57B)      SLJ(4T)         . EXIT                          02627

* START CLOCK IF NOT RUNNING

7T      SLJ(N)          ENI(0)          . EXIT/ENTRY                    02630
        ENI1(0)         ENQ(0)          .                               02631
        LDA(Z)          ISK1(40000B)    . WAIT                          02632
        EQS(Z)          SLJ(7T)         . SENSE CLOCK RUNNING           02633
        STQ(Z+50B)      LDA(R12)        . INITIALIZE TIME               02634
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        STA(Z)            EXF(100B)         . START CLOCK                     02635
        EXF(1000B)        SLJ(7T)           . EXIT                            02636

* REWIND SPECIFIED MEDIUM

1V      SLJ(N)            SLJ(L+2)          . EXIT/ENTRY                      02637
2V      ZRO(0)            ZRO(0)            . MEDIUM                          02640
        ENI1(0)           ISK1(3000B)       . DELAY                           02641
        LDA(2V)           SLJ4(1G)          . GET NUMERIC DESIGNATOR          02642
        IJP1(L+2)         IJP2(L+13)        . SENSE TAPE REFERENCE            02643
        SLJ(1VA)          ZRO(0)            . EXIT                            02644
        IJP1(L+1)         SLJ(1VA)          .                                 02645
        LDA(U1)           ENI(0)            . SET SELECT CODES                02646
        IJP1(L+1)         LDA(U0)           .                                 02647
        IJP1(1VA)         ARS(24)           .                                 02650
        STA(T)            SAL(L+5)          .                                 02651
        ENA2(0)           ALS(3)            .                                 02652
        INA(2)            ADD(T)            .                                 02653
        SAU(L+2)          INA(3)            .                                 02654
        SAU(L+2)          SLJ4(1FLAG)       .                                 02655
        EXF(N)            EXF7(N)           . REWIND TAPE                     02656
        EXF(N)            SLJ(1VA)          . EXIT                            02657
        IJP2(L+1)         SLJ(1VA)          .                                 02660
        IJP2(L+10)        ENA(0)            . SENSE PAPER TAPE REFERENCE      02661
        STA(T+1)          ENA(T+2)          . PROCESS PAPER TAPE              02662
        SAL(Z+2)          SLJ4(1FLAG)       .                                 02663
        EXF(21210B)       ENI1(100)         . PUNCH LEADER                    02664
        EXF2(T+1)         EXF7(21B)         .                                 02665
        IJP1(L-1)         ENI(0)            . LOOP                            02666
        ENA(57B)          STA(T)            .                                 02667
        ENA(45B)          STA(T+1)          .                                 02670
        EXF2(T)           EXF7(21B)         . PUNCH CARRIAGE RETURN           02671
        SLJ(1VA)          ZRO(0)            . EXIT                            02672
        INI2(-3B)         IJP2(1VA)         . SENSE MEMORY REFERENCE          02673
        LDA(4S)           SAL(6S)           . REWIND MEMORY FILE              02674
1VA     EXF(62560B)       SLJ(1V)           .                                 02675

* REWIND TAPE WITH INTERLOCK

3V      SLJ(N)            SLJ(L+2)          . EXIT/ENTRY                      02676
4V      ZRO(0)            ZRO(0)            . MEDIUM                          02677
        ENI1(0)           ISK1(3000B)       . DELAY                           02700
        LDA(4V)           SLJ4(1G)          . GET NUMERIC DESIGNATOR          02701
        IJP1(L+1)         SLJ(3V)           . SENSE TAPE REFERENCE            02702
        IJP1(L+1)         SLJ(3V)           .                                 02703
        LDA(U1)           IJP1(L+2)         . SET SELECT CODES                02704
        LDA(U0)           SLJ4(1FLAG)       .                                 02705
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       ARS(24)        STA(T)         .                             02706
       SAL(L+4)       ENA2(0)        .                             02707
       ALS(3)         INA(2)         .                             02710
       ADD(T)         SAU(L+2)       .                             02711
       INA(5)         SAU(L+2)       .                             02712
       EXF(N)         EXF7(N)        . REWIND WITH INTERLOCK       02713
       EXF(N)         ENI(0)         .                             02714
       EXF(62560B)    SLJ(3V)        . EXIT                        02715

3VV    SLJ4(3V)       ZRO(0)         .                             02716
       SLJ(Z+33B)     ZRO(0)         . EXIT                        02717

* WRITE ENDFILE MARKER ON SPECIFIED MEDIUM

5V     SLJ(N)         SLJ(L+2)       . EXIT/ENTRY                  02720
6V     ZRO(0)         ZRO(0)         . MEDIUM                      02721
       ENI1(0)        ISK1(3000B)    . DELAY                       02722
       LDA(6V)        SLJ4(2G)       . GET NUMERIC DESIGNATOR      02723
       IJP1(L+1)      SLJ(L+13)      . SENSE TAPE REFERENCE        02724
       IJP1(L+1)      SLJ(5V)        .                             02725
       LDA(U1)        SLJ4(1FLAG)    . SET SELECT CODES            02726
       IJP1(L+1)      LDA(U0)        .                             02727
       IJP1(5V)       INA(3)         .                             02730
       SAU(L+6)       SCL(777B)      .                             02731
       SAL(L+4)       SAL(L+5)       .                             02732
       SAL(T)         ENA2(0)        .                             02733
       ALS(3)         INA(2)         .                             02734
       ADD(T)         SAU(L+1)       .                             02735
       EXF(N)         EXF7(N)        . WRITE TAPE ENDFILE          02736
       EXF(N)         EXF7(N)        .                             02737
       EXF(62560B)    SLJ(5V)        . EXIT                        02740
       ENA2(-6)       AJP1(5V)       . SENSE MEMORY REFERENCE      02741
       LIL1(5S)       INI1(-1)       . WRITE MEMORY ENDFILE        02742
       LDQ(R4)        LDA(5S)        .                             02743
       STQ7(6S)       IJP1(L)        .                             02744
       RAD(6S)        SLJ(5V)        . EXIT                        02745

* BACKSPACE SPECIFIED MEDIUM

7V     SLJ(N)         SLJ(L+2)       . EXIT/ENTRY                  02746
8V     ZRO(0)         ZRO(0)         . MEDIUM                      02747
       ENI1(0)        ISK1(3000B)    . DELAY                       02750
       LDA(8V)        SLJ4(1G)       . GET NUMERIC DESIGNATOR      02751
       IJP1(L+2)      IJP2(L+15)     . SENSE TAPE REFERENCE        02752
       SLJ(7V)        ZRO(0)         .                             02753
       IJP1(L+1)      SLJ(7V)        .                             02754
       LDA(U1)        SLJ4(1FLAG)    . SET SELECT CODES            02755
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       IJP1(L+1)        LDA(U0)        .                                 02756
       ALS(24)          ENI(0)         .                                 02757
       IJP1(7V)         INA(6)         .                                 02760
       SAU(L+6)         SCL(777B)      .                                 02761
       SAL(L+4)         SAL(L+5)       .                                 02762
       SAL(T)           ENA2(0)        .                                 02763
       ALS(3)           INA(2)         .                                 02764
       ADD(T)           SAU(L+1)       .                                 02765
       EXF(N)           EXF7(N)        . BACKSPACE TAPE                  02766
       EXF(N)           EXF7(N)        .                                 02767
       EXF(62560B)      SLJ(7V)        . EXIT                            02770
       ENA2(-5)         AJP1(7V)       . SENSE MEMORY REFERENCE          02771
       LDA(5S)          RSB(6S)        . BACKSPACE MEMORY                02772
       SLJ(7V)          ZRO(0)         . EXIT                            02773

* BCD WRITE ROUTINE

1W     SLJ(N)           SLJ4(2G)       . EXIT/ENTRY                      02774
       IJP1(L+6)        IJP2(L+2)      . SENSE NO MEDIUM REFERENCE       02775
       SLJ(1W)          ZRO(0)         . EXIT                            02776
       IJP2(L+1)        SLJ(6W)        . SENSE TYPEWRITER OUTPUT         02777
       IJP2(L+1)        SLJ(7W)        . SENSE PAPER TAPE OUTPUT         03000
       ENA2(-3)         AJP(9W)        . SENSE MEMORY OUTPUT             03001
       SLJ(5W)          ZRO(0)         .                                 03002
       IJP1(10W)        ENI(0)         . SENSE MAGNETIC TAPE OUTPUT      03003
       ENA2(-2)         AJP(2W)        . SENSE CARD OUTPUT               03004
       SLJ(5W)          ZRO(0)         .                                 03005
2W     SLJ4(3W)         ZRO(0)         . PROCESS CARD PUNCH              03006
       ENA(W+24)        SLJ4(1FLAG)    .                                 03007
       EXF(24004B)      SAL(Z+2)       .                                 03010
       EXF2(W)          EXF7(14004B)   .                                 03011
       EXF(62560B)      SLJ(1W)        . EXIT                            03012
3W     SLJ(N)           ENI(0)         . FORM CARD IMAGE                 03013
       ENA(1)           ALS(7)         .                                 03014
       STA(T)           ENI1(0)        .                                 03015
4W     ENQ(77B)         LDL1(W)        .                                 03016
       STA(T+1)         LIL2(T+1)      .                                 03017
       LDA2(G0)         ALS(6)         . TABLE LOOKUP                    03020
       ENI2(23)         STA(T+1)       .                                 03021
       INI2(-1)         ENI(0)         .                                 03022
       SSH(T+1)         SLJ(L+2)       . TAG CONTROL WORDS               03023
       LDA(T)           RAD2(W)        .                                 03024
       ENI(0)           IJP2(L-3)      . LOOP                            03025
       ENQ(77B)         LDL1(W+40)     .                                 03026
       STA(T+1)         LIL2(T+1)      .                                 03027
       LDA2(G0)         ALS(6)         . TABLE LOOKUP                    03030
       ENI2(23)         STA(T+1)       .                                 03031
       INI2(-1)         ENI(0)         .                                 03032
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        SSH(T+1)        SLJ(L+2)        . TAG CONTROL WORDS              03033
        LDA(T)          RAD2(W+1)       .                                03034
        ENI(0)          IJP2(L-3)       . LOOP                           03035
        LDA(T)          ALS(1)          .                                03036
        STA(T)          ENI(0)          . SHIFT MARK                     03037
        ISK1(39)        SLJ(4W)         . LOOP                           03040
        LDA1(W)         ARS(7)          .                                03041
        STA1(W)         ENI(0)          . POSITION RESULTS               03042
        ISK1(23)        SLJ(L-2)        . LOOP                           03043
        SLJ(3W)         ZRO(0)          . RETURN                         03044
5W      ENA(E12)        SLJ(1E)         . ERROR EXIT                     03045
6W      ENA(R5)         SLJ4(7G)        . PROCESS TYPEWRITER             03046
        EXF(21110B)     ENI(0)          .                                03047
        ENA(T+1)        SAL(Z+2)        .                                03050
        ENI2(119)       ENI(0)          .                                03051
        LDA2(W)         INA(-20B)       . SEARCH FOR TERMINAL BLANKS     03052
        AJP1(L+1)       IJP2(L-1)       .                                03053
        SIU2(L+13)      ENI2(0)         . STORE LENGTH OF ENTRY          03054
        LDA2(W)         STA(T)          .                                03055
        LIL1(T)         LDQ1(K0)        . TABLE LOOKUP                   03056
        QLS(6)          LDL(77B)        .                                03057
        AJP1(L+4)       ENI(0)          . JUMP ON UPPER CASE             03060
        EXF7(11141B)    SLJ(L+6)        . JUMP ON LOWER CASE             03061
        ENA(57B)        STA(T)          .                                03062
        SLJ(L+3)        ZRO(0)          .                                03063
        EXF7(11140B)    SLJ(L+3)        .                                03064
        ENA(47B)        STA(T)          .                                03065
        EXF2(T)         EXF7(21B)       . CARRIAGE SHIFT                 03066
        QLS(6)          STQ(T)          .                                03067
        EXF2(T)         EXF7(21B)       . PRINT CHARACTER                03070
        ISK2(N)         SLJ(L-12)       . LOOP                           03071
        EXF7(11141B)    SLJ(1W)         . SENSE CARRIAGE DOWN            03072
        ENA(57B)        STA(T)          . SHIFT CARRIAGE DOWN            03073
        EXF2(T)         EXF7(21B)       .                                03074
        SLJ(1W)         ZRO(0)          . EXIT                           03075
7W      ENI2(119)       SLJ(L+2)        . PROCESS PAPER TAPE             03076
        ZRO(0)          ZRO(0)          . CURRENT CASE                   03077
        ENA(T+1)        SLJ4(1FLAG)     .                                03100
        EXF(21210B)     SAL(Z+2)        .                                03101
        LDA2(W)         INA(-20B)       . SEARCH FOR TERMINAL BLANKS     03102
        AJP1(L+1)       IJP2(L-1)       .                                03103
        SIU2(L+18)      ENI2(0)         . STORE LENGTH OF ENTRY          03104
        LDA2(W)         STA(T)          .                                03105
        INA(-20B)       AJP1(L+2)       . SENSE SPACE                    03106
        ENA(4)          SLJ(L+13)       .                                03107
        LIL1(T)         LDQ1(K0)        . TABLE LOOKUP                   03110
        QLS(18)         LDL(77B)        .                                03111
        AJP1(L+5)       ENI(0)          . JUMP ON CARRIAGE UP            03112
        LDA(L-12)       AJP(L+8)        . JUMP ON CARRIAGE DOWN          03113
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        ENA(0)          STA(L-13)       .                               03114
        ENA(57B)        STA(T)          .                               03115
        SLJ(L+4)        ZRO(0)          .                               03116
        LDA(L-16)       AJP1(L+4)       .                               03117
        ENA(77B)        STA(L-17)       .                               03120
        ENA(47B)        STA(T)          .                               03121
7WA     EXF2(T)         EXF7(21B)       . CARRIAGE SHIFT                03122
        QLS(6)          LDL(77B)        .                               03123
        STA(T)          ENI(0)          .                               03124
7WB     EXF2(T)         EXF7(21B)       . PUNCH CHARACTER               03125
        ISK2(N)         SLJ(L-17)       . LOOP                          03126
        ENA(45B)        STA(T)          .                               03127
7WC     EXF2(T)         EXF7(21B)       . PUNCH CARRIAGE RETURN         03130
        EXF(62560B)     SLJ(1W)         . EXIT                          03131
9W      SLJ4(4G)        ZRO(0)          . PROCESS MEMORY                03132
        LDA(5S)         INA(-1)         .                               03133
        SAU(L+2)        INA(1)          .                               03134
        LDQ1(W)         STQ7(6S)        .                               03135
        ISK1(N)         SLJ(L-1)        .                               03136
        RAD(6S)         SLJ(1W)         . EXIT                          03137
10W     LDA(U1)         ENI(0)          . PROCESS MAGNETIC TAPE         03140
        IJP1(L+1)       LDA(U0)         .                               03141
        IJP1(5W)        STA(T+10)       .                               03142
        SLJ4(4G)        ZRO(0)          . ASSEMBLE WRITE BUFFER         03143
        ENA(W+15)       SAU(3Y)         .                               03144
        ENA2(0)         ALS(3)          .                               03145
        ADD(T+10)       INA(2)          .                               03146
        SLJ4(1Y)        ZRO(0)          .                               03147
        SLJ(1W)         ZRO(0)          . EXIT                          03150

* TAPE READING ROUTINE

1X      SLJ(N)          SLJ4(1FLAG)     . EXIT/ENTRY                    03151
        ENI(0)          SAU(4X)         .                               03152
        SCL(777B)       SAL(4X)         . INITIALIZE                    03153
        SAL(5X)         SAL(11X)        .                               03154
        INA(3)          SAU(8X)         .                               03155
        INA(2)          SAU(9X)         .                               03156
        INA(1)          SAU(11X)        .                               03157
        INA(1)          SAU(7X)         .                               03160
        LRS(18)         ENA(0)          .                               03161
        LLS(3)          SAL(2X)         .                               03162
        SAL(3X)         SAU(12X)        .                               03163
        LLS(39)         LDQ(R16)        .                               03164
        STA(T+10)       LDA(5X)         .                               03165
        SSU(T+10)       STA(5X)         .                               03166
        LDA(6X)         SSU(T+10)       .                               03167
        STA(6X)         ENI1(4)         .                               03170
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      LDA(R6)          ENI(0)          .                              03171
      STA1(R+10)       IJP1(L)         .                              03172
2X    ENA(N)           SAL(N)          .                              03173
3X    ENI2(4)          LIL1(N)         .                              03174
4X    EXF(N)           EXF7(N)         . SELECT UNIT                  03175
5X    EXF(R)           EXF7(N)         . ACTIVATE CHANNEL             03176
6X    EXF(N)           LDA(R)          .                              03177
      SUB(R4)          LLS(48)         .                              03200
      INI1(-1)         LDA1(Z)         .                              03201
      INI1(1)          SUB(R4)         .                              03202
7X    EXF7(N)          SLJ(15X)        . SENSE ENDFILE                03203
8X    EXF7(N)          SLJ(L+4)        . SENSE PARITY ERROR           03204
9X    EXF7(N)          SLJ(10X)        . SENSE LENGTH ERROR           03205
      QJP1(1XA)        AJP(3X)         . SENSE FOR BAD RECORD         03206
      SLJ(1XA)         ZRO(0)          . EXIT                         03207
      IJP2(L+2)        SLJ(14X)        . SENSE FIVE PARITY ERRORS     03210
10X   IJP2(L+1)        SLJ(13X)        . SENSE FIVE LENGTH ERRORS     03211
      AJP(3X)          QJP(3X)         . SENSE FOR BAD RECORD         03212
11X   EXF(N)           EXF7(N)         . BACKSPACE                    03213
12X   LIL1(N)          SLJ(4X)         . RETURN TO REREAD             03214
13X   ENA(T6)          SLJ(17X)        . SET TO INDICATE TROUBLE      03215
14X   ENA(T9)          SLJ(17X)        .                              03216
15X   ENA(T12)         SLJ(13X)        .                              03217
16X   ENA(10X)         SAL(9X)         . SET TO REREAD NEW LENGTH     03220
      LIU1(2X)         ENA(R+10)       .                              03221
      SIL1(L-1)        SAL7(2X)        .                              03222
      SAU(6X)          SAL(10R)        .                              03223
      SLJ(11X)         ZRO(0)          . RETURN TO REREAD             03224
17X   SLJ4(5G)         ZRO(0)          . TROUBLE EXIT                 03225
      AJP(1XA)         AJP3(3X)        . SENSE ACTION TO TAKE         03226
      SLJ(11X)         ZRO(0)          .                              03227
18X   SLJ4(5G)         ZRO(0)          . TROUBLE EXIT                 03230
      AJP(3X)          AJP3(3X)        . SENSE ACTION TO TAKE         03231
      SLJ(11X)         ZRO(0)          .                              03232
1XA   EXF(62560B)      SLJ(1X)         .                              03233

* TAPE WRITING ROUTINE

1Y    SLJ(N)           SLJ4(1FLAG)     . EXIT/ENTRY                   03234
      ENI(0)           SAU(2Y)         .                              03235
      SAU(9Y)          SCL(777B)       . INITIALIZE                   03236
      SAL(2Y)          SAL(4Y)         .                              03237
      SAL(8Y)          SAL(10Y)        .                              03240
      INA(3)           SAU(5Y)         .                              03241
      SAU(11Y)         INA(2)          .                              03242
      SAU(6Y)          SAU(12Y)        .                              03243
      INA(1)           SAU(8Y)         .                              03244
      SAU(7Y)          SAU(13Y)        .                              03245
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         LRS(15)             SAL(3Y)         .                                   03246
         SAL(15Y)            ENQ(0)          .                                   03247
         LLS(39)             LDQ(R16)        .                                   03250
         STA(T+10)           LDA(4Y)         .                                   03251
         SSU(T+10)           STA(4Y)         .                                   03252
         LDA(10Y)            SSU(T+10)       .                                   03253
         STA(10Y)            ENI(0)          .                                   03254
2Y       EXF(N)              EXF7(N)         . SELECT UNIT                       03255
3Y       ENA(N)              SAL(N)          .                                   03256
4Y       EXF(W)              EXF7(N)         . ACTIVATE CHANNEL                  03257
5Y       EXF7(N)             SLJ(17Y)        . SENSE PARITY ERROR                03260
6Y       EXF7(N)             SLJ(19Y)        . SENSE LENGTH ERROR                03261
7Y       EXF7(N)             SLJ(1YA)        . SENSE END OF TAPE                 03262
         SLJ(16Y)            ZRO(0)          .                                   03263
8Y       EXF(N)              EXF7(N)         . BACKSPACE                         03264
9Y       EXF(N)              SLJ(14Y)        . SELECT UNIT                       03265
10Y      EXF(W+64)           EXF7(N)         . WRITE BAD RECORD INDICATION       03266
11Y      EXF7(N)             SLJ(2Y)         . SENSE PARITY ERROR                03267
12Y      EXF7(N)             SLJ(2Y)         . SENSE LENGTH ERROR                03270
13Y      EXF7(N)             SLJ(2Y)         . SENSE END OF TAPE                 03271
         SLJ(16Y)            ZRO(0)          .                                   03272
14Y      ENI1(53)            LDA(R4)         .                                   03273
         STA1(W+64)          IJP1(L)         . SET BAD RECORD INDICATION         03274
15Y      ENA(64)             RAD(N)          .                                   03275
         IJP2(10Y)           SLJ(3Y)         .                                   03276
16Y      ENA(T21)            SLJ4(5G)        . TROUBLE EXIT                      03277
         AJP(2Y)             ENI2(0)         . SENSE ACTION TO TAKE              03300
         AJP3(1YA)           SLJ(8Y)         .                                   03301
17Y      ENA(T18)            SLJ4(5G)        . TROUBLE EXIT                      03302
18Y      AJP3(1YA)           ENI2(1)         . SENSE ACTION TO TAKE              03303
         AJP(8Y)             ENI2(0)         .                                   03304
         SLJ(8Y)             ZRO(0)          .                                   03305
19Y      ENA(T15)            SLJ4(5G)        . TROUBLE EXIT                      03306
         SLJ(18Y)            ZRO(0)          .                                   03307
1YA      EXF(62560B)         SLJ(1Y)         .                                   03310

* SERVICE ROUTINE CALL SERVICE

1SR      SLJ(N)              ENI1(0)         .                                   03311
         ENA(1)              STA(2C)         .                                   03312
         LDA1(COPYS)         STA1(3C)        .                                   03313
         ISK1(7B)            SLJ(L-1)        .                                   03314
         SLJ4(1C)            ZRO(0)          .                                   03315
         SLJ(1SR)            ZRO(0)          .                                   03316

* INTERRUPT HANDLER
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1SENS EXF7(32505B)      SLJ(3ST00)       . 160-3/4 INTERRUPT                   03317
      EXF7(52505B)      SLJ(5ST00)       . 160-5/6 INTERRUPT                   03320
      EXF7(00111B)      SLJ(1CLR)        . DIVIDE FAULT                        03321
      EXF7(00121B)      SLJ(1CLR)        . SHIFT FAULT                         03322
      EXF7(00131B)      SLJ(1A)          . OVERFLOW FAULT                      03323
      EXF7(00141B)      SLJ(1CLR)        . EXPONENT FAULT                      03324
      SLJ(L+1)          SLJ(N)           . CR INTERRUPT                        03325
      SLJ(L+1)          SLJ(N)           . CH 3 READY READ                     03326
      SLJ(L+1)          SLJ(N)           . CH 5 READY READ                     03327
      SLJ(L+1)          SLJ(N)           . CH 4 READY WRITE                    03330
      SLJ(L+1)          SLJ(N)           . CH 6 READY WRITE                    03331
      SLJ(L+1)          SLJ(N)           . CARD READER/PUNCH READY             03332
      SLJ(L+1)          SLJ(N)           . PAPER TAPE READER END OF TAPE       03333
      SLJ(L+1)          SLJ(N)           . DD65 DISPLAY INTERRUPT              03334
      SIU1(L+2)         LIU1(Z+7)        . ERROR INTERRUPT                     03335
      SIL1(L+1)         ENI(0)           .   LOCK-OUT                          03336
      ENI1(N)           SLJ(N)           . RETURN TO PROGRAM                   03337

1CLR  EXF(70B)          SLJ(Z+7)         . CLEAR ARITHMETIC FAULT              03340
2CLR  EXF(11100B)       SLJ(Z+7)         . CLEAR CR INTERRUPT                  03341

* CHANNEL 3-4 SATELLITE INTERRUPT ROUTINE

3ST00 STA(3TEMP)        STQ(3QTMP)       .SAVE A/Q REGISTERS                   03342
      SIU3(3PX22)       EXF(32505B)      .SAVE B3 / REL. INTERRUPT             03343
      LDA(3IBC)         STA(3STBF)       .SET 1 WORD INPUT CONTROL             03344
      ENA(3STCC)        SAL(3STBB)       .SET LOOP SWITCH                      03345
3STAA EXF(32503B)       EXF7(32000B)     .SEL 160-1604 / WAIT READY            03346
      SIU1(3PXIT)       EXF7(42000B)     .WAIT WRITE READY                     03347
      LDA(3STBF)        SAL(Z+3)         .SET TERMINAL ADDRESS                 03350
      ARS(30B)          SAU(L+2)         .SET INITIAL ADDRESS                  03351
      EXF(32001B)       EXF(42504B)      .READ BINARY / 160 ACTION REQ.        03352
      EXF3(N)           EXF7(31B)        .ACTIVATE / WAIT CH INACTIVE          03353
      ENI(0)            EXF7(32000B)     .PASS / WAIT READY TO READ            03354
      ENA(3EXIT)        EXF(42500B)      .SET FOR LOOP / REL DIRECT            03355
3STBB SIL2(3PXIT)       SLJ(N)           .SWITCH                               03356
3STCC EXF7(42521B)      SLJ(3STDD)       .EXIT NO F2 / GO CASE S.R.            03357
      SSK(3STBF)        SLJ(L+2)         .INPUT OR OUTPUT / GO OUTPUT          03360
      SAL(3STBB)        SLJ(3STAA)       .SWITCH TO EXIT / GO INPUT            03361
3STCD EXF(42503B)       EXF7(42000B)     .SEL 1604-160 / WAIT READY            03362
      ENI(0)            EXF7(32000B)     .WAIT READY READ                      03363
      LDA(3STBF)        SAL(Z+4)         .SET TERMINAL ADDRESS                 03364
      ARS(30B)          SAU(L+2)         .SET INITIAL ADDRESS                  03365
      EXF(42001B)       EXF(42504B)      .WRITE BINARY / 160 ACTION REQ.       03366
      EXF4(N)           EXF7(41B)        .ACTIVATE / WAIT CH INACTIVE          03367
      ENI(0)            EXF7(42000B)     .PASS / WAIT READY TO WRITE           03370
3EXIT EXF(42500B)       EXF(42520B)      .REL DIRECT /REL F2                   03371
      EXF(32502B)       EXF(42502B)      .TAKE READ AND WRITE CONTROL          03372
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3PXIT ENI1(N)         ENI2(N)         .RESTORE B1 AND B2                    03373
3PX22 ENI3(N)         LDA(3TEMP)      .RESTORE B3 / A REG.                  03374
      LDQ(3QTMP)      SLJ(Z+7)        .RESTORE Q REG / EXIT VIA 7           03375
3STDD LDA(3STBF)      SAL(L+7)        .PRIME FOR ARG INPUT                  03376
      SAL(3STED)      ENI1(1)         .   AND S.R. RETURN JUMP              03377
      SSK(3STBF)      SLJ(3STEE)      .CHECK ARG MODE / GO LDA ARG.         03400
      ALS(3B)         ARS(33B)        .PACK                                 03401
      INA(-1B)        ENI(0)          .   THE                               03402
      SAU(L+2)        ARS(17B)        .      ARGUMENT                       03403
      AJP(3STEE)      SAU(L+2)        .         ADDRESSES                   03404
      ENA1(N)         STA1(N)         .            INTO                     03405
      ISK1(N)         SLJ(L-1)        .               SUBROUTINE            03406
3STEE ALS(3B)         ARS(33B)        .POSITION A REGISTER ARGUMENT         03407
3STED ENI(0)          SLJ4(N)         .GO EXECUTE SUBROUTINE                03410
      SLJ(3EXIT)      ZRO(0)          .GO EXIT FROM INTERUPT                03411
3IBC  ZRO(3STBF)      ZRO(3TEMP)      .INITIAL BUFFER CONTROL               03412
3STBF ZRO(0)          ZRO(0)          .BUFFER CELL                          03413
3TEMP ZRO(0)          ZRO(0)          .TEMP STORAGE                         03414
3QTMP ZRO(0)          ZRO(0)          .TEMP STORAGE FOR Q REGISTER          03415

* CHANNEL 5-6 SATELLITE INTERRUPT ROUTINE

5ST00 STA(5TEMP)      STQ(5QTMP)      .SAVE A/Q REGISTERS                   03416
      SIU3(5PX22)     EXF(52505B)     .SAVE B3 / REL. INTERRUPT             03417
      LDA(5IBC)       STA(5STBF)      .SET 1 WORD INPUT CONTROL             03420
      ENA(5STCC)      SAL(5STBB)      .SET LOOP SWITCH                      03421
5STAA EXF(52503B)     EXF7(52000B)    .SEL 160-1604 / WAIT READY            03422
      SIU1(5PXIT)     EXF7(62000B)    .WAIT READY WRITE                     03423
      LDA(5STBF)      SAL(Z+5)        .SET TERMINAL ADDRESS                 03424
      ARS(30B)        SAU(L+2)        .SET INITIAL ADDRESS                  03425
      EXF(52001B)     EXF(62504B)     .READ BINARY / 160 ACTION REQ.        03426
      EXF5(N)         EXF7(51B)       .ACTIVATE / WAIT CH INACTIVE          03427
      ENI(0)          EXF7(52000B)    .PASS / WAIT CH INACTIVE              03430
      ENA(5EXIT)      EXF(62500B)     .SET FOR LOOP / REL DIRECT            03431
5STBB SIL2(5PXIT)     SLJ(N)          .SWITCH                               03432
5STCC EXF7(62521B)    SLJ(5STDD)      .EXIT NO F2 / GO CASE S.R.            03433
      SSK(5STBF)      SLJ(L+2)        .INPUT OR OUTPUT / GO OUTPUT          03434
      SAL(5STBB)      SLJ(5STAA)      .SWITCH TO EXIT / GO INPUT            03435
5STCD EXF(62503B)     EXF7(62000B)    .SEL 1604-160 / WAIT READY            03436
      ENI(0)          EXF7(52000B)    .WAIT READY READ                      03437
      LDA(5STBF)      SAL(Z+6)        .SET TERMINAL ADDRESS                 03440
      ARS(30B)        SAU(L+2)        .SET INITIAL ADDRESS                  03441
      EXF(62001B)     EXF(62504B)     .WRITE BINARY / 160 ACTION REQ.       03442
      EXF6(N)         EXF7(61B)       .ACTIVATE / WAIT CH INACTIVE          03443
      ENI(0)          EXF7(62000B)    .PASS / WAIT READY TO WRITE           03444
5EXIT EXF(62500B)     EXF(62520B)     .REL DIRECT / REL F2                  03445
      EXF(52502B)     EXF(62502B)     .TAKE READ AND WRITE CONTROL          03446
5PXIT ENI1(N)         ENI2(N)         .RESTORE B1 AND B2                    03447
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5PX22 ENI3(N)           LDA(5TEMP)          .RESTORE B3 / A REG.
      LDQ(5QTMP)        SLJ(Z+7)            .RESTORE Q REG / EXIT VIA 7
5STDD LDA(5STBF)        SAL(L+7)            .PRIME FOR ARG INPUT
      SAL(5STED)        ENI1(1)             .   AND S.R. RETURN JJMP
      SSK(5STBF)        SLJ(5STEE)          .CHECK ARG MODE / GO LDA ARG.
      ALS(3B)           ARS(33B)            .PACK
      INA(-1B)          ENI(0)              .   THE
      SAU(L+2)          ARS(17B)            .      ARGUMENT
      AJP(5STEE)        SAU(L+2)            .         ADDRESSES
      ENA1(N)           STA1(V)             .            INTO
      ISK1(N)           SLJ(L-1)            .               SUBROUTINE
5STEE ALS(3B)           ARS(33B)            .POSITION A REGISTER ARGUMENT
5STED ENI(0)            SLJ4(V)             .GO EXECUTE SUBROUTINE
      SLJ(5EXIT)        ZRO(0)              .GO EXIT FROM INTERUPT
5IBC  ZRO(5STBF)        ZRO(5TEMP)          .INITIAL BUFFER CONTROL
5STBF ZRO(0)            ZRO(0)              .BUFFER CELL
5TEMP ZRO(0)            ZRO(0)              .TEMP STORAGE
5QTMP ZRO(0)            ZRO(0)              .TEMP STORAGE FOR Q REGISTER

* 160 SATELLITE LIBRARY CALL ROUTINE HANDLER

160CL STA(2NAME)        EXF(63511B)         . STORE NAME / TURN OFF LIGHT 1
      LDA(BLOCKS)       STA(160TP)          . SET BLOCK READ LIMIT
      LDA(2X)           STA(2XSTR)          . PROTECT RESIDENT
      LDA(5X)           STA(5XSTR)          .     BINARY READ
      LDA(6X)           STA(6XSTR)          .         ROUTINE
      LDA(2NAME)        ENI1(10B)           . SEARCH IDENT TABLE
      EQS1(IDENT)       SLJ(1LAST)          .     TO IDENTIFY PROGRAM
      LDA1(SIZE)        SAU(L+2)            . SET NR OF WORDS TO BE READ
      SSK(1SWT)         SLJ(1LAST)          . EXIT IF BINARY READ LOCKOUT
      ENI3(N)           LDA(2V)             . SAVE REWIND ARGUMENT
      STA(2VSTR)        ENA(13)             .
      SAL(2V)           SLJ4(1V)            . REWIND LIBRARY TAPE
      LDA(2VSTR)        STA(2V)             . RESTORE REWIND ARG.
160LA ENI(0)            SLJ4(160IN)         . GO READ LIB BLOCK
      RSO(160TP)        AJP(1LAST)          . CHECK FOR LIMIT
      SSK(2VSTR)        SLJ(1SRCH)          . CHECK HIT FLAG
160LB LDA1(SATBUF)      STA(2NAME)          . SET WORD IN OUTPUT BUFFER
      IJP3(160UT)       SLJ(1LAST)          . CHECK IF LAST WORD
160LC ISK1(65B)         SLJ(L-2)            . LOOP UNTIL BLOCK IS EXHAUSTED
      SLJ(160LA)        ZRO(0)              . GO READ NEXT BLOCK
160UT SLJ4(160WD)       ZRO(0)              . GO WRITE OUT WORD
      SLJ(160LC)        ZRO(0)              . RETURN TO READ NEXT WORD
160WD SLJ(N)            ENA(2XSTR)          . WRITE OUT WORD ROUTINE
      EXF(62503B)       EXF7(52000B)        .
      SAL(Z+6)          EXF7(52000B)        .
      EXF(62001B)       EXF(62504B)         .
      EXF6(2NAME)       EXF7(51B)           .
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      ENI(0)             EXF7(62000B)      .                                   03525
      EXF(62560B)        SLJ(160WD)        .                                   03526
160IN SLJ(N)             ENA(SATBUF)       . LIB BLOCK READ ROUTINE            03527
      SAU(5X)            INA(65B)          .                                   03530
      SAU(2X)            SAU(6X)           .                                   03531
      LDA(TAPE1)         SLJ4(1X)          .                                   03532
      ENI1(0)            SLJ(160IN)        .                                   03533
1SRCH LDA(SATBUF)        AJP(160LA)        . SEARCH TAPE FOR NAME              03534
      SCM(2NAME)         AJP1(160LA)       . LOOP UNTIL HIT                    03535
      ENI1(1)            ENA(-0)           . SET HIT FLAG                      03536
      STA(2VSTR)         SLJ(160LB)        . GO TRANSMIT LIBRARY ROUTINE       03537
1LAST EXF(62540B)        SLJ4(160WD)       . GO WRITE OUT LAST WORD            03540
      LDA(2XSTR)         STA(2X)           . RESTORE                           03541
      LDA(5XSTR)         STA(5X)           .     TAPE READ                     03542
      LDA(6XSTR)         STA(6X)           .         ROUTINE                   03543
      EXF(53511B)        EXF(62560B)       . TURN ON LIGHT 1 / REL COMM 1      03544
      SSK(1SWT)          SLJ(1CALL)        . EXIT, LOCK-OUT SET                03545
      EXF(32005B)        SLJ(1CALL)        . REWIND LIB / NORMAL EXIT          03546
2NAME ZRO(0)             ZRO(0)            .                                   03547
2XSTR ZRO(0)             ZRO(0)            .                                   03550
5XSTR ZRO(0)             ZRO(0)            .                                   03551
6XSTR ZRO(0)             ZRO(0)            .                                   03552
2VSTR ZRO(0)             ZRO(0)            .                                   03553
160TP ZRO(0)             ZRO(0)            .                                   03554

* SATELLITE MONITOR JOB ROUTINE HANDLER

1SWTH SLJ(N)             LDA(2M)           . SAVE ON-LINE                      03555
      SAL(8V)            SLJ4(7V)          .    MONITOR JOB                    03556
      ENI(0)             SLJ4(7V)          .        DESCRIPTION                03557
      ENI(0)             ENQ(7777B)        .                                   03560
      LDA(2M)            STA(2MSTR)        . SAVE MONITOR                      03561
      LDA(3M)            STA(3MSTR)        .     INPUT/OUTPUT                  03562
      LDA(4K)            STA(4KSTR)        .         ARGUMENTS                 03563
      ENA(2INTM)         SAL(Z+25B)        . SET FOR ERRORS TO SATELLITE       03564
      ENA(66B)           STA(4K)           . SET SAT FLEX ERROR OUTPUT         03565
      ENA(1INTM)         SAL(11MA)         . SET SWITCH DIVERTER               03566
      LDL(0SWT)          ENQ(65B)          . CHECK IF DESIRE PUNCH OUTPUT      03567
      AJP(L+1)           STQ(3M)           . IF SO, SET OUTPUT ARG             03570
      STQ(2M)            LDA(2SWTH)        . SET FLEX INPUT                    03571
      STA(7RA)           LDA(3SWTH)        . PRIME FLEX READ                   03572
      STA(7WA)           STA(7WB)          . PRIME FLEX WRITE                  03573
      STA(7WC)           ENA(2RCVR)        .                                   03574
      SAU(Z+30B)         ENA(11MA)         . SET TROUBLE RECOVERY              03575
      INA(-2B)           SAU(1SWTH)        . SET TO READ SAT JOB               03576
      SLJ(1SWTH)         ZRO(0)            . RETURN                            03577
2SWTH SLJ4(1STRD)        ZRO(0)            . JUMP TO READ FLEX                 03600
3SWTH SLJ4(1STWT)        ZRO(0)            . JUMP TO WRITE FLEX                03601
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2MSTR ZRO(0)            ZRO(0)          .                                   03602
3MSTR ZRO(0)            ZRO(0)          .                                   03603
4KSTR ZRO(0)            ZRO(0)          .                                   03604
1INTM SLJ(N)            ENA(1RCVR)      . SET SWITCH TO RECOVER             03605
      SAL(11MA)         SLJ(L-1)        .                                   03606
2INTM ENA(-0)           STA(1ERSW)      .                                   03607
      SLJ(Z+25B)        ZRO(0)          .                                   03610
1STRD SLJ(N)            LDA(2STRD)      . SATELLITE READ ROUTINE            03611
      STA(5STBF)        LDA(L-1)        .                                   03612
      ALS(24)           EXF(2000B)      .                                   03613
      SAL(3STRD)        ENA(3STRD)      .                                   03614
      SAU(Z+7)          ENA(5EXIT)      .                                   03615
      SAL(5STBB)        SIU1(5PXIT)     .                                   03616
      SIL2(5PXIT)       SIU3(5PX22)     .                                   03617
      STQ(5QTMP)        ENI(0)          .                                   03620
      EXF(62540B)       SLJ(5STAA)      .                                   03621
2STRD ZRO(T)            ZRO(T+1)        . FLEX I/O BUFFER                   03622
3STRD EXF(1000B)        SLJ(N)          .                                   03623
1STWT SLJ(N)            LDA(2STRD)      . SATELLITE WRITE ROUTINE           03624
      STA(5STBF)        LDA(L-1)        .                                   03625
      ALS(24)           EXF(2000B)      .                                   03626
      SAL(3STWT)        ENA(3STWT)      .                                   03627
      SAU(Z+7)          SIU1(5PXIT)     .                                   03630
      SIL2(5PXIT)       SIU3(5PX22)     .                                   03631
      STQ(5QTMP)        EXF(62560B)     .                                   03632
      SLJ(5STCD)        ZRO(0)          .                                   03633
3STWT EXF(1000B)        SLJ(N)          . RE-START CLOCK                    03634
1RCVR SLJ(N)            ENA(77B)        . RECOVERY ROUTINE                  03635
      STA(T)            SLJ4(1STWT)     . WRITE COMPLETION  FLAG TO 160     03636
2RCVR EXF(21240B)       ENQ(-0)         . RECOVERY                          03637
      LDA(2MSTR)        STA(2M)         .                                   03640
      LDA(3MSTR)        STA(3M)         .                                   03641
      ENA(2A)           SAU(Z+30B)      .                                   03642
      LDA(3RCVR)        STA(7RA)        .                                   03643
      LDA(4RCVR)        STA(7WA)        .                                   03644
      STA(7WB)          STA(7WC)        .                                   03645
      LDA(4KSTR)        STA(4K)         .                                   03646
      EXF(52502B)       EXF(62502B)     . TAKE READ AND WRITE CONTROL       03647
      ENA(11A)          SAL(Z+25B)      . RE-SET MESSAGE HANDLER            03650
      ENA(1SWTH)        SAL(11MA)       .                                   03651
      STQ(R)            STQ(M+39)       .                                   03652
      STQ(0SWT)         SLJ(11MAA)      . RETURN TO 1604 MONITOR JOB        03653
3RCVR EXF1(T)           EXF7(11B)       .                                   03654
4RCVR EXF2(T)           EXF7(21B)       .                                   03655

* DD65 SCOPE SIMULATOR FOR AN ON-LINE PRINTER

65DPY SLJ1(4A)          EXF(77010B)     . SELECT 1604 TO DD65               03656
```

```
        SIU1(65DPX)        SIL2(65DPX)       . SAVE INDEXES                       03657
        SIU3(65PX1)        SIL4(65PX1)       .                                    03660
        SIU5(65PX2)        SIL6(65PX2)       .                                    03661
        STA(DPYAS)         STQ(DPYQS)        . SAVE A/Q                           03662
        EXF7(77010B)       SLJ(4A)           . SENSE DD65 AVAILABLE               03663
        SSK(DDSWT)         SLJ(4A)           . TEST PRINTER IN RUN/STOP MODE      03664
        ENI1(0)            ENQ(7000B)        .                                    03665
        ENA(20B)           RAD1(ITAB)        .                                    03666
        SSU(ND65R)         STA1(ITAB)        .                                    03667
        ISK1(31)           SLJ(L-2)          .                                    03670
        ENI1(32)           OUT1(ITAB)        .                                    03671
        ENA(400B)          ENI1(32)          .                                    03672
        ENQ(777B)          MEQ1(ITAB)        .                                    03673
        LDA1(ITAB)         STA(BUF65+11B)    .                                    03674
        ENQ(77B)           ENI2(9)           .                                    03675
        ENI3(0)            ENA(0)            .                                    03676
        ENI1(0)            SLJ(65SSU)        .                                    03677
65CYL   INI1(1)            ENI(0)            .                                    03700
65SSU   SSU1(W)            ALS(6)            .                                    03701
        ISK3(5)            SLJ(65CYL)        .                                    03702
        IJP2(L+1)          SLJ(65OUT)        .                                    03703
        ALS(6)             INI1(1)           .                                    03704
        SSU1(W)            STA2(BUF65)       .                                    03705
        ENA(0)             SLJ(65CYL)        .                                    03706
65OUT   LDA(BUF65)         SSU(65XIT)        .                                    03707
        STA(BUF65)         ENI(0)            .                                    03710
        ENI1(10)           OUT1(BUF65)       .                                    03711
65DPX   ENI1(N)            ENI2(N)           . RESTORE INDEXES                    03712
65PX1   ENI3(N)            ENI4(N)           .                                    03713
65PX2   ENI5(N)            ENI6(N)           .                                    03714
        LDA(DPYAS)         LDQ(DPYQS)        . RESTORE A/Q                        03715
65XIT   SLJ(4A)            ZRO(0)            . EXIT                               03716

        END
        END
```

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1
RESIDENT, 0, 4504, 0
INPUTCDI, 2, 600, 0
OUTPUTCD, 2, 600, 0
INPUTBIN, 2, 26, 0
OUTPUTBN, 2, 27, 0
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PAUSE   , 0, 23, 0
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EFLOFFLO, 2, 177, 0
EFLOFFIX, 2, 245, 0
EFIXFFIX, 2, 60, 0
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COSF    , 1, 113, 0
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ASECF   , 1, 141, 0
CSCF    , 1, 117, 0
ACSCF   , 1, 134, 0
SINH    , 1, 113, 0
ASINH   , 1, 144, 0
COSH    , 1, 102, 0
ACOSH   , 1, 163, 0
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CTNH    , 1, 105, 0
ACTNH   , 1, 77, 0
SECH    , 1, 76, 0
ASECH   , 1, 200, 0
CSCH    , 1, 115, 0
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LOGF     , 1, 103, 0
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ABSF     , 1, 5, 0
XABSF    , 1, 5, 0
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SIGNF    , 2, 11, 0
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STEP     , 1, 7, 0
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         , 752, 42001, 67600
         , 710, 10105, 0
65-4A545, 400, 40673, 42070
+0 .1818, 27, 76512, 30110
-Y4 JY*Y, 72, 56504, 10240
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*PA55)-P, 40, 14131, 12170
```

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40A744E4, 547, 30402, 20413
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TUK  7+2, 50, 53310, 62176
  +9/I +, 641, 10424, 25071
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4       , 732, 15061, 66003
        , 710, 11575, 0
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 Q1M    , 100, 100, 1
-ZH1 XC4, 220, 65030, 12070
-Q-RA5 Z, 405, 72230, 2057
-       , 232, 40002, 42311
- S2HAU/, 444, 45457, 26606
B5S2HAXQ, 403, 22027, 26211
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        , 423, 12001, 2225
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FORTRUN , 5, 14000, 0
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MTTEST  , 0, 62045, 0
COMPSYM , 4, 22751, 0
CONPAC  , 2, 353, 0
REMCON  , 2, 355, 0
```

ENCLOSURES

A. IDENTIFICATION

TITLE: 160 Grafplot Routine

PROGRAMMERS: R.L. HOGG / D.C. GLOVER

ORGANIZATION: U.S. Naval Postgraduate School
Monterey, California

DATE: 1 April 1963

B. PURPOSE

To plot multiple curved graphs on the CalComp 165 plotter. Graph titling and axes annotation are provided. The input to the routine is a specially prepared magnetic tape, see the CDC 160-A program of the same name for the input tape format. This routine is a truncated version of the 160-A program, interpolation has been deleted in order to operate in the reduced memory of the 160 computer.

C. USAGE

1. Normal Operation
    a. Load the specially prepared magnetic tape input (See 160-A write-up) on unit #1. Select unit for Binary parity.
    b. Load bi-octal grafplot program at address 0000.
    c. Position the plotter pen at position where the lower left corner of the graph is to be plotted.

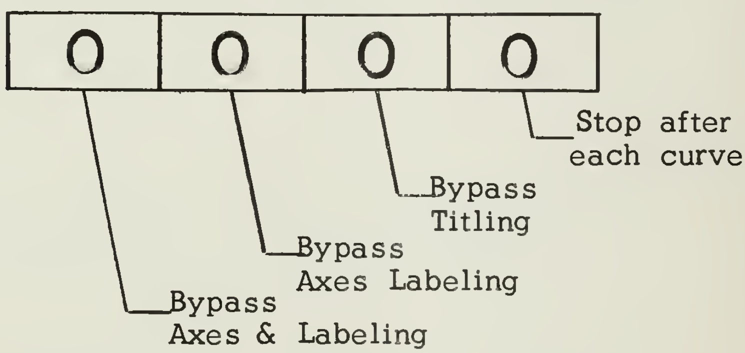
d. Starting Addresses

Location	Contents of "A"	Results
0000	# of graphs to be plotted	Reads tape and plots # of graphs called for. If A=0, all graphs will be processed.
0001		Skip to next graph.
0002		Backspace to beginning of current graph.
0003		Back-up one graph.
0004		Same as a 0000 start.
0010		Rewind tape to Load Pt.
0040	Graph # in A	Skips forward N-1 graphs, into position to plot graph #N.

e. Optional Running Modes

Four modes of operation are provided. To select the mode desired, execute a start at cell 0020 with the following "A" register arguments set. This primes the routine for the mode selected. Remaining graphs will be plotted in this mode, operations as previously described.

"A" REGISTER FORMAT for MODE SELECTION



NOTE: Entry of any non-zero octal number, constitutes setting an argument.

f. Normal Stops

Location	Situation
0004	Normal halt after operation is completed
1157	Optional halt after each curve. Run to continue.

g. Error Stops

0130	*Parity - Title location data
0135	**
0173	*Parity - Title character
0200	**
0373	*Parity - Axed data
0400	**
1125	*Parity - Curve data
1163	**

* Re-Select Start to continue questionable plot.

** Unable to Continue / Skip to next graph to proceed.

A. IDENTIFICATION

TITLE: 160-A Graph Plot Program

DATA CENTERS IDENT: *B001.

PROGRAMMERS: Maurice D. Weir, Milton Spritzer, D. W. McIlhenny, Harry Farnsworth

ORGANIZATION: Fleet Numerical Weather Facility, Monterey, California

DATE: 15 August 1962

REVISED: 4 February 1963, by R. Hogg and D. Glover

B. PURPOSE

To plot N curves on the CONTROL DATA 165 Plotter, complete with titling information and annotated axes, from a specially prepared magnetic tape. SEE TAPE FORMAT.

C. USAGE

1. Computer Operational Procedure

a. Normal operation:

1) Specially prepared magnetic tape on Unit #1. (SEE TAPE FORMAT)

2) Load bi-octal tape at location 0, bank 0. Set direct bank equal to zero.

3) Position the plotter pen such that the cross-hairs line up in the following INITIAL POSITION: LEFT most VERTICAL LINE and one of the HALF-INCH HORIZONTAL LINES on the graph paper.

CAUTION: User should indicate this POSITION in relation to a previously plotted graph. This prevents the forthcoming graph from being written over a previously plotted one.

4) Starting Address

Location	Contents of A	Result
0000	No. of graphs to be plotted.	Reads tape and plots number of graphs called for. If A = 0, tape will be completely processed.

Location	Contents of A	Result
0001		Skip to next file.
0002		Backspace to beginning of current graph.
0003		Back up one complete graph.
0010		Rewind tape to load point.
0040	Graph No. N	Skip N-1 graphs, and stop

NOTE: Normal halt for above operations is location 4.

5) Plotter pen will position itself, draw and annotate the horizontal and vertical axes. Pen will finish by driving back such that the cross-hairs are now lined up with the INTERSECTION of the HORIZONTAL and VERTICAL AXES just drawn.

6) Plotter will plot N curves with their identification (if any). Pen will finish by driving back to the INTERSECTION of the HORIZONTAL and VERTICAL AXES.

7) Normal Stop

(P) = 0004 - Normal halt for all options.

8) Error Stops

a) The following error stops, which occur during the read from the magnetic tape, have two options. These options are:

i) RUN for questionalbe plot, or

ii) SET selective jump switch #2 and RUN. This will result in by-passing that particular section of the program (e.g., titling, annotation of axes, or curve).

The error stops are:
P = 0135 - Parity error in title locations
P = 0176 - Parity error in titling data
P = 0401 - Parity error in axes data
P = 1144 - Parity error in curve data

b) The following error stops, which occur during the read from the magnetic tape, have no options. If any occur, operator should check to make certain magnetic tape unit is on unit #1, tape is at load point, tape is ready, 163-2 units are on. Then set (P) according to step 4).

The error stops in this category are:
P = 0142 - titling location
P = 0203 - titling data
P = 0406 - Axes data
P = 1200 - curve data

P = 1103 - error in number of interpolations. RUN.

b. Operational variations:

The Graph Plot program contains some special operational procedures which allow for variations in the graph by altering the Normal operation.

1) Option to by-pass titling:

After the plotter pen has been positioned in the previously defined INITIAL POSITION, SET selective jump switch #2. Set (P) according to step a.4) and RUN. Titles will be read from magnetic tape but not plotted. Program will make NORMAL STOP P = 0361, and pen will not have moved.

2) Option to by-pass axes annotation:

With plotter pen at AXES INTERSECTION and at SPECIAL STOP P = 0361, SET selective jump switch #2 and RUN (do not clear). Axes data will be read from magnetic tape but not plotted. Program will make NORMAL STOP P = 1051, and pen will not have moved.

3) Option to PLOT - one-curve-STOP:

With plotter pen at AXES INTERSECTION and at SPECIAL STOP P = 1051, SET selective stop switch #1 and RUN. After curve is plotted, pen will drive back to AXES INTERSECTION, and program will make SPECIAL STOP P = 1174 before the next curve record is read in. Pen-ink may now be changed for next curve, etc. RUN to read in and plot next curve.

4) Option to by-pass one curve at a time:

1136

At SPECIAL STOP P = 1051 , SET selective jump switch #2 and RUN. Curve data will be read in, and program will make SPECIAL STOP P = ~~1065~~. If selective jump switch # 2 remains set when RUN is set, next curve will be read in, and program will again make SPECIAL STOP P = ~~1065~~. If selective jump switch # 2 is not set when RUN is set, next curve will be read in and plotted, etc.

2. Space Requirements

a. Program: 0 - 4137 in Bank zero.

b. Curve data and interpolation: 100 - 7777 in Bank one.

3. Temporary Storage

Locations 50 - 77 in Bank zero.

4. Tape Mountings

Magnetic tape must be read from unit # 1.

5. Caution to Users

Do not step through program. Read write-up carefully before using the Graph Plot Program.

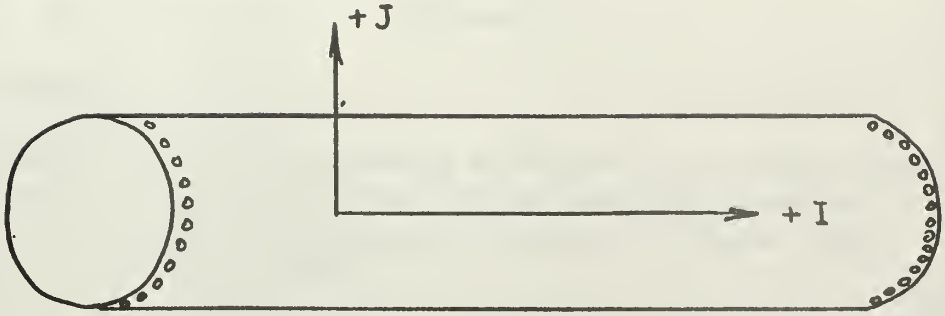
D. TAPE FORMAT

Each magnetic tape to be used by this program must have one or more records (as indicated) in each of the following categories:

I	Titling data	- multiple records
II	Axes data	- one record
III	Curve data	- multiple records
IV	End of File.	

These records must be on the magnetic tape in the order defined above and in the format to be specified below.

AXES DEFINED AS FOLLOWS:



I = horizontal axis

J = vertical axis

I Titling data

1. Record 0

a. 12 bit binary mode

b. 4 160-A words (i.e., 1 1604 word)

c. **Format:**

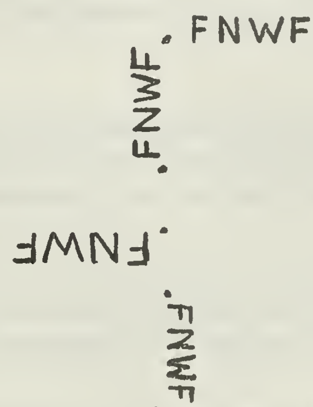
word 0 (I_T)	I distance of initial pt. of first title from the INITIAL POSITION, given as a signed Δ I movement in inches times 100_d.
word 1 (J_T)	J distance of initial pt. of first title from the INITIAL POSITION, given as a signed Δ J movement in inches times 100_d.
word 2	Orientation of titles defined as follows:

0004

0001

0002

0003



word 3	Number of lines in title given as a 12 bit integer. (OCTAL)

2. Records 1 to T

a. BCD characters in 6-bit binary mode.

b. Maximum length of 120_d characters where 119_d is number of characters to be plotted.

c. **Format:**

character 0	Size of letters in title line. Size X is defined to be "X times one-tenth inch". The width of a letter is approximately equal to its height.

character 1 … character 119 — Title line in BCD. <u>Not</u> necessary to fill out this line

II <u>Axes data</u>

a. 1 record in 12 bit binary mode

b. 20_d 160-A words

c. <u>Format:</u>

word 0 (I_H) — I distance of initial point of horizontal axis from the INITIAL POSITION, given as a signed ΔI movement in inches times 100_d.

word 1 (J_H) — J distance of initial point of horizontal axis from the INITIAL POSITION, given as a signed ΔJ movement in inches times 100_d.

word 2 (L_H) — Length of the horizontal axis given as a signed ΔI movement from where the axis begins in inches times 100_d.

word 3 (I_{HL}) — I distance of initial point of first horizontal axis label from the INITIAL POSITION, given as a signed ΔI movement in inches times 100_d.

word 4 (J_{HL}) — J distance of initial point of first horizontal axis label from the INITIAL POSITION, given as a signed ΔJ movement in inches times 100_d.

word 5 (I_{HL}) — I distance between horizontal labels, given as a signed ΔI movement in inches times 100_d.

word 6 (V_H) — First <u>value</u> which is to be plotted for the horizontal axis labeling. This is a <u>signed 12 bit integer</u> which will be converted to BCD. Its maximum value cannot exceed $\pm 999_d$.

word 7 (V_H) — <u>Value</u> of the ΔI distance between horizontal axis labels given as a <u>signed 12 bit integer</u>.

word 8 (N_H) — Number of horizontal axis labels to be plotted. This is always a positive 12 bit integer.

word 9 (S_H)	<u>Upper six bits</u>: Size of letters in horizontal axis labeling.
(O_H)	<u>Lower six bits</u>: Orientation of horizontal axis labels. Orientation previously defined.
word 10 (I_V)	I distance of initial point of vertical axis from the INITIAL POSITION, given as a signed ΔI movement in inches times 100_d.
word 11 (J_V)	Vertical axis analogy to word 1.
word 12 (L_V)	Vertical axis analogy to word 2.
word 13 (I_{VL})	Vertical axis analogy to word 3.
word 14 (J_{VL})	Vertical axis analogy to word 4
word 15 (J_{VL})	Vertical axis analogy to word 5
word 16 (V_V)	Vertical axis analogy to word 6.
word 17 (V_V)	Vertical axis analogy to word 7.
word 18 (N_V)	Vertical axis analogy to word 8.
word 19 (S_V)	<u>Upper six bits</u>: Size of letters in vertical axis labeling.
(O_V)	<u>Lower six bits</u>: Orientation of vertical axis labels.

III <u>Curve data</u>

a. Multiple records in 12 bit binary mode.

b. m words long where m has maximum value of 3677_8.

c. Each I, J must be given as a distance from the INITIAL POSITION, as a signed $\Delta I, \Delta J$ movement in inches times 100_d.

d. Format:

word 0	0000
word 1	0000
word 2	0000
word 3	number of interpolations (00 - 07)
word 4	I_1
word 5	J_1
word 6	I_2
word 7	J_2
⋮	
word m-5	3777 end flag
word m-4	3777 end flag
word m-3	curve name. 4 BCD characters,
word m-2	packed two to a word.
word m-1	upper six bits: letter size of curve name lower six bits: orientation of curve name

IV End of File

E. TIMING

Each graph takes 2 - 3 minutes to plot, including titling, annotated axes, and interpolation.

F. METHOD

1. General

All location points on the graph are interpreted as being relative to the (0, 0) INITIAL POSITION previously defined. All lengths, intervals, etc. must have the appropriate sign according to the definition of the (I, J) axes. Information is plotted as follows: titles, horizontal axis, horizontal axis annotation, vertical axis, vertical axis annotation, and finally the curve(s) (with interpolations, if any). The program uses TAP for reading the magnetic tape input, OVDR for driving to a position with the pen up, LINE for joining given points with the pen down, and LABEL for titling.

2. Titles

The initial points from the magnetic tape input are used to position the pen in the desired location on the graph for the first title. The

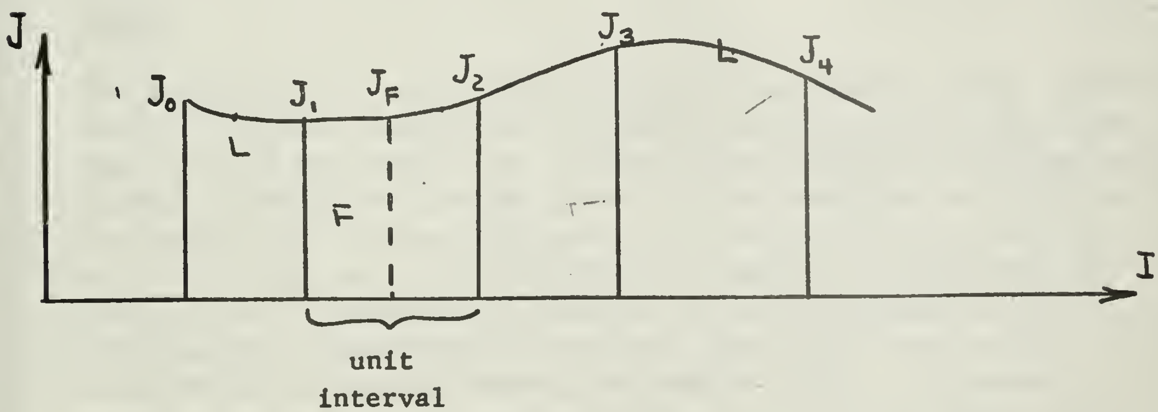
first title is plotted, and if there are additional titles, the program calculates the appropriate spacing between lines according to the orientation and the letter size of the incoming title. The program keeps track of all pen movements so that when the last title is plotted, pen drives back to the (0, 0) INITIAL POSITION.

3. <u>Annotation of Axes</u>

The initial points from the magnetic tape input are used to position the pen in the desired location on the graph for the start of the horizontal axis. The axis is drawn, and then the pen moves into position to begin the first horizontal axis label. This first label is plotted according to its size and orientation; the remaining labels being computed and then plotted at the desired intervals, based upon the initial value, the scaling, and the number of labels desired. At the completion of the horizontal axis annotation, the pen positions itself at the start of the vertical axis. The axis is drawn and labelled as in the horizontal axis annotation. The program keeps track of all pen movements so that when the vertical axis annotation has been completed, pen drives back to the INTERSECTION of the HORIZONTAL and VERTICAL AXES.

4. <u>Interpolation</u>

This is a four-point interpolation method based on the Bessel Interpolation Equations.



The interpolation scheme fits the four points to a quadratic curve, computing the interpolated point J_F by the following equation:

$$J_F = J_1 + F\,(J_2 - J_1) + \frac{F\,(F-1)}{4}\quad (J_0 + J_3 - J_2 - J_1)$$

The program uses F = 1/2.

This interpolation method depends upon equal I intervals. Since it cannot perform an interpolation between the first and last pairs of J values, a linear interpolation is performed at these two positions (marked "L" in the diagram). This linear interpolation occurs at the half-interval of both end pairs, which allows the user to make more than one interpolation by maintaining equality of I intervals.

The number of interpolations X desired must comply with the following inequality:

$$\frac{\Delta I}{2^x} > \frac{1}{100}$$

The program has set the maximum number of interpolations as 07. If the number of interpolations indicated (see TAPE FORMAT, "curve data") exceeds this maximum, program will interpolate 07 times only, and indicate an error in the number of interpolations indicated.

Caution: Because of the necessary storage space for the curve data points, the maximum number of (I, J) points that can be plotted after interpolation is 980_d.

WARNING: Since the interpolation depends upon equal spacing of the I intervals, any curve which does not have equally spaced points will not be properly interpolated. This applies to multiple-valued functions and asymptotic values.

5. Curves

The first (I, J) curve data point from the magnetic tape input is used to position the pen in the desired location on the graph for the start of the curve plot. Curve is then plotted by joining successive points by a straight line. At the completion of plotting the curve (with the desired number of interpolations, if any), program labels curve (if desired) with indicated orientation and letter size. Program keeps track of all pen movements so that when the curve labelling is completed, pen drives back to the INTERSECTION of the HORIZONTAL and VERTICAL AXES. If another curve is to be plotted, program proceeds in the same manner as for the first curve. When the final curve is plotted, pen will be positioned at the INTERSECTION of the HORIZONTAL and VERTICAL AXES.

Caution: User may not desire a curve label, in which case blanks are indicated on the magnetic tape for the four BCD characters.

(see TAPE FORMAT, "curve data.") Nevertheless, an orientation and letter size must still be indicated since they are required by the LABEL subroutine.

FINIS

A. IDENTIFICATION

TITLE: 1604 Graph Plotting Subroutine

DATA CENTERS IDENT: *A002.

PROGRAMMERS: R. L. Hogg and D. C. Glover

ORGANIZATION: Naval Postgraduate School, Monterey, California

DESCRIPTION WRITE-UP: E. A. Campbell, CDC

DATE: 5 March 1963

B. PURPOSE

To write data on a magnetic tape for off-line plotting on the CONTROL DATA 165 plotter. The tape format is compatible with the 160-A Graph Plot Program (Data Centers Ident *B001.) which is used to drive the 165 plotter.

C. USAGE

1. Calling Sequence

   a. FORTRAN-62

```
CALL GRAFPLOT(MODCURV, NUMPTS, X, Y, LABEL, INTERPS, SFX, SFY, IXOFFS, IYOFFS,
IWIDE, IHIGH, MODE, TITLESIZ, TITLE1, TITLE2, ······, TITLEN)

CALL AUTOGRAF(MODCURV, NUMPTS, X, Y, TITLE1, TITLE2, ······,
TITLEN)
```

   b. CODAP1

```
Either:     ENA     (MODCURV)
            ENQ     (NUMPTS)
            RTJ     GRAFPLOT
      +     ZRO     X
            ZRO     Y
            ZRO     LABEL
            ZRO     INTERPS
            ZRO     SFX
            ZRO     SFY
            ZRO     IXOFFS
            ZRO     IYOFFS
            ZRO     IWIDE
            ZRO     IHIGH
            ZRO     MODE
            ZRO     TITLESIZ
            ZRO     TITLE1
            ZRO     TITLE2
             .
             .
             .
            ZRO     TITLEN
```

```
Or:          ENA     (MODCURV)
             ENQ     (NUMPTS)
             RTJ     AUTOGRAF
      +      ZRO     X
             ZRO     Y
             ZRO     TITLE1
              .
              .
              .
             ZRO     TITLEN
      +      RTJ     ERROR
```

2. Input Parameters

Parameter Name	Value	Description
*MODCURV	0	First and last curve for this graph
	1	First curve of many
	2	Intermediate curve
	3	Final curve for this graph
NUMPTS	1-900	Number of points
X		Location of X coordinates
Y		Location of Y coordinates
LABEL	4 BCD Char.	BCD label for curve
	0	No label
	-0	Automatic sequencing of curves for No. 1-8.
INTERPS	0	No interpolation between coordinate points
	1-7	One to 7 interpolations between coordinate points
SFX	0	Program will find best scale factor
	Fl. Pt. Number	Scale factor for X **
SFY	0	Program will find best scale factor
	Fl. Pt. Number	Scale factor for Y **
IXOFFS	1-10	Number of inches to offset X axis
	0	No offset
IYOFFS	1-10	Number of inches to offset Y axis
	0	No offset
IWIDE	1-10	Length of X axis - inches
IHIGH	1-120	Length of Y axis - inches

*If MODCURV is 2 or 3, then only the first 6 parameters need to be repeated.

**Scale factor = 100/units per inch on plotted output.

Parameter Name	Value	Description
MODE	0	Automatically calculate best axes offset for origin at lower left
	1	Locate origin at center
	2	Locate origin at lower left
	3	Locate origin at upper left
	4	Locate origin at upper right
	5	Locate origin at lower right
TITLESIZ	1-24	Multiplier for lettering size. Basic size is .1 inches.
TITLE1		Location of first title. Title array must be at least 10 words of BCD characters. Fill unused characters with blanks.
. . .		
TITLEN		Location of Nth title array

3. Space Requirements

1120 decimal locations

6. Error Returns

No error return is used, however, an error return point is skipped in order to be compatible with FORTRAN subroutines.

8. Input/Output Tape Mountings

Plot data output on logical 48 through CO-OP Monitor.

9. Input/Output Tape Formats

See 160-A Graph Plot Program write-up for details. The basic form is titling information, axes annotation, and curve data with an end of file separating graphs. No special end of tape mark is used to terminate the tape.

13. Cautions to Users

a. If scale factors are defined, then the appropriate axes offsets should also be defined.

b. The normal width of the plotter paper is 10 inches. For best results, do not use a horizontal axis length greater than 9 inches.

c. The number of interpolations N required must comply with the following inequality: $\Delta I/2^n > 1/100$ where ΔI is the uniform (equal) increment along the horizontal axis. See reference for further details.

14. Equipment Configuration

CO-OP Monitor configuration with at least one output tape available.

15. References

This program uses 160-A Graph Plot Program (Data Centers Ident No. *B001) as a subset to drive the 165 plotter.